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Heavy Metals in Traditionally Used Fruits Among the Lakota

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HEAVY METALS IN TRADITIONALLY USED FRUITS AMONG THE LAKOTA

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This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy in Biological Sciences with Plant Science Specialization degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ABBREVIATIONS

ANZFA	Australian New Zealand Food Authority (changed to FSANZ)
AAS	Atomic Absorption Spectroscopy
ATSDR	Agency for Toxic Substances and Disease Registry (US Department of Health and Human Services agency)
BMD	Bench mark dose (US EPA)
BMDL	Lower-bound confidence limit of BMD (US EPA)
BONAP	The Biota of North America Program (North America Vascular Flora)
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (US Congressional Superfund Act of 1980)
CDC	Centers for Disease Control (US Department of Health and Human Services)
EC	European Commission (EFSA)
EFSA	European Food Safety Authority
EUR-Lex	European lexicon (a trade name for a business that provides distribution of EC data through a webpage)
FAO	Food and Agriculture Organization (UN)
FSANZ	Food Standards Australia New Zealand
GELs	Generally Expected Levels (of elements, FSANZ, formerly ANZFA)
ICP-MS	Inductively Coupled Plasma-Mass Spectroscopy
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrometry
IRIS	Integrated Risk Information System, US EPA
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LOAEL	Lowest-Observed-Adverse-Effect Level (reference dose, US EPA, IRIS)
MCL	Maximum Contaminant Level (standard set for drinking water, US EPA)

MCLG Maximum Contaminant Level Goal (goal standard set for drinking water, US EPA)

ML Maximum Level of Codex Alimentarius Commission permitted in food (WHO/FAO)

ML Maximum Level of specified contaminant in food (FSANZ, formerly ANZFA)

MRL Minimum Risk Level (non-cancerous health effect, ATSDR of CDC)

ND North Dakota

NE Nebraska

NOAEL No-Observed-Adverse-Effect Level (without statistical significance, US EPA, IRIS)

NPDWR National Primary Drinking Water Regulations (or primary standards US EPA)

NPL National Priorities List (ATSDR)

NRCS Natural Resources Conservation Service (USDA)

NSF National Science Foundation (US)

OLC Oglala Lakota College (Kyle, SD, administrative headquarters location, *Piya Wiconi*

OSPRA Oglala Sioux Parks & Recreation Authority (Kyle, SD)

OSSPEEC Oglala Lakota College, South Dakota State University, South Dakota School of Mines and Technology Pre-Engineering Education Collaborative (NSF grant project)

OST NRRA Oglala Sioux Tribe, Natural Resources Regulatory Agency (Pine Ridge, Reservation, SD)

PEEC Pre-Engineering Education Collaborative (NSF grant project, see OSSPEEC)

PRG Preliminary Remediation Goals (US EPA, CERCLA/RCRA, Superfund sites)

PRR Pine Ridge Reservation

PTWI	Provisional tolerable weekly intake (WHO/FAO)
RBC	Risk-Based Concentration Table (US EPA)
RfD	Oral reference dose (US EPA, IRIS)
RCRA	Resource Conservation and Recovery Act (US)
RSL	Regional screening level (US EPA, CERCLA)
SARA	Superfund Amendments and Reauthorization Act
SD	South Dakota
SDSMT	South Dakota School of Mines and Technology (Rapid City, SD)
SDSU	South Dakota State University (Brookings, SD)
SL	Screening level (US EPA, CERCLA)
SSL	Soil Screening Level (US EPA, CERCLA)
TOSNAC	Technical Outreach Service to Native American Communities
TT	Treatment Technique
UN	United Nations
US	United States
USDA/ NASS	United States Department of Agriculture / National Agricultural Statistics Service
US EPA	United States Environmental Protection Agency
US FDA	United States Food and Drug Administration
USGS	United States Geological Survey
WEERC	Water and Environmental Engineering Research Center laboratory (at SDSU)
WHO	World Health Organization (UN public health division)
WHO/FAO	World Health Organization/Food and Agriculture Organization

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ABSTRACT

HEAVY METALS IN TRADITIONALLY USED FRUITS AMONG THE LAKOTA

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Heavy metals concentrations in soils and plants on and near Pine Ridge Reservation (PRR), SD, are a cause of concern to Oglala Lakota tribal government, particularly because of current and past uranium mining nearby, as well as familiarity with occasional selenium poisoning in livestock. In this study, concentrations of As, Ba, Pb, Se, and U were determined using ICP-OES for selected traditionally edible berries and small fruits, and the soils in which they grow. Results indicated that the heavy metals are likely of natural origin, and ingestion of these culturally important fruits at levels reported in interviews among the Lakota on nearby Rosebud Reservation generally do not exceed US CDC Minimal Risk Levels (MRLs) for chronic oral ingestion, with the possible exception of As in chokecherries and wild rosehips, and U in wild plum and wild rosehips. No US CDC MRL for Pb has been established, because they deem such a standard as inappropriate at the current state of knowledge, with which I agree. However, fruits were compared to the WHO/FAO Maximum Level (ML) permitted for berries and small fruit, with 8.5 per cent of fruit samples from PRR exceeding that standard. Results showed that fruits were generally lower in heavy metals than the soils in which they grew on PRR, with the exception of Se. Some detected concentrations of Se in fruits and other plant tissues at 9 of 15 sites indicated possible bioaccumulation. Wild rosehips on and near PRR were generally higher in heavy metals concentrations than in comparison samples from Brookings County, SD, where Pb concentrations were comparable or slightly higher, and one Se sample was unusually high. Concentrations of heavy metals in soils on PRR ranked substantially lower in As, Ba and Pb and much higher in Se and U compared to USGS arithmetic means and ranges for the conterminous United States established by Shacklette and Boerngen (1984). This study produced preliminary baseline concentrations for fruits and the soils in which they grow on and near PRR and for estimated oral exposure levels based on interviews from nearby Rosebud Reservation, against which other research may be compared.

Key words: ICP-OES, traditional fruits, ethnobotany, soils, Native diet, Pine Ridge and Rosebud Reservations

OVERVIEW OF DISSERTATION

This study began as an outgrowth of my researching heavy metals concentrations in traditionally edible fruits on Pine Ridge Reservation (PRR) in South Dakota from 2011 to 2013, in a project partially funded by the National Science Foundation (NSF). Through interviews with residents of nearby Rosebud Reservation, I estimated the levels of consumption and absorption of the fruits in Chapter 1. Finding that little research existed concerning modern-day uses of traditionally edible fruits and the role they currently play in Lakota culture, another motivation for the Chapter 1 study was to fill that void. Thereby, I updated the ethnobotanical work of others, particularly Melvin R. Gilmore (1919, 1991).

In Chapter 2, I determined concentration levels of heavy metals in traditionally edible fruits and the soils in which they grew on PRR and, thereby, produced estimated baselines for both in a screening study. In addition, I examined possible health implications for those who gather, consume, or otherwise use those fruits and parts of the plants of interest, using data reported in Chapter 1.

CHAPTER 1: ETHNOBOTANY OF THE LAKOTA IN SOUTHWESTERN SOUTH DAKOTA

INTRODUCTION

While some older studies existed concerning the uses of traditionally edible fruits among the Lakota-speaking Teton Sioux, I found scant information about modern cultural practices. The current study provides up-to-date ethnobotanical information from interviews with local residents of Rosebud Reservation concerning their uses of plants of interest. Although particularly focused upon fruits, interviewees described certain other plant parts as foods, beverages, medicines, tonics, religious paraphernalia and crafts, as well as describing the contexts in which they use them currently. Participants also shared preparation methods and short vignettes about their cultural ties to traditionally edible fruits (Appendix A).

Although I recorded interviews on Rosebud Reservation, I collected the actual plant samples on nearby PRR, where permission for interviews remains pending. Residents of the two participating reservations are Teton Sioux (the western Sioux), but they comprise different sub-tribes, *Sicangu Oyate (Brule)* and *Oglala*, respectively.

Concerning the traditionally edible fruit plants selected for this study, they are as follows by common English names and their Latinized species names: buffaloberry (*Shepherdia argentea* [Pursh] Nutt.), buffalo currant (*Ribes aureum,* Pursh var. *villosum* DC.), chokecherry (*Prunus virginiana* L. var. *melanocarpa* [A. Nelson] Sarg.), riverbank grape (*Vitis riparia* Michx.), wild plum (*Prunus americana* Marsh.), and wild roses (*Rosa spp.*).

Other traditionally edible fruits, such as serviceberry (*Amelanchier alnifolia* Nutt.), wild raspberry (*Rubus idaeus* L.), wild strawberry (*Fragraria virginiana* Duchne.), and groundcherry (*Physalis spp.*) would have been of interest, but they were absent or uncommon on PRR. In addition, interviewees on nearby Rosebud Reservation seldom reported those species or their uses in the modern day, due to their scarcity or absence since the locale is too prone to drought.

HYPOTHESIS

The hypothesis of this study is that modern day uses of traditionally edible fruits remain important in Lakota culture (Chapter 1) and increases their risk of exposure to certain heavy metals (restated in Chapter 2).

OBJECTIVES

1. Determine the presence and availability of selected traditionally edible wild fruits among the Lakota in southwestern South Dakota.
2. Determine the extent to which modern Lakota on Rosebud Reservation gather or otherwise obtain those wild fruits.
3. Estimate amounts ingested or other exposures to those wild fruits and related plant parts among the Lakota on Rosebud Reservation, in light of the measured concentration levels of selected heavy metals in such fruits on nearby PRR reported in Chapter 2 of this study.
4. Determine the modern-day uses and cultural importance of the plants of interest among the Lakota on Rosebud Reservation.

BOUNDARIES OF THE STUDY AREA

ROSEBUD RESERVATION

The overall boundaries for the ethnobotanical study encompassed the Rosebud Reservation in south-central South Dakota as depicted in Figure 1. Today's Rosebud Reservation, located in Todd County, South Dakota, is home of a large segment of the *Sicangu Oyate* (*Brule*) Lakota. In addition, the reservation holds trust lands in nearby Mellette, Tripp, Gregory, and Lyman Counties. Historically, in a complicated series of realignments, the boundaries of Todd County changed significantly through time, as noted by Thorndale and Dollarhide (1987).

PINE RIDGE RESERVATION

While I conducted no ethnobotanical interviews on PRR, all of the plant specimens for this study, discussed in Chapter 2, were collected there. Currently, the PRR, home to the Oglala Lakota tribe, comprises all of Shannon County and the southern part of Jackson County with some trust lands in adjacent Bennett County to the east (Fig. 1).

Reservation and county boundaries changed through time, which is of interest because herbarium labels designate plant voucher specimens by county. Therefore, it is worth noting that the boundaries of the reservation in 1910 included all or parts of the following counties: extinct Washington, Shannon, extinct Washabaugh, and Bennett (Long, 2011). According to historian J. Leonard Jennewein, Congress opened nearby

Mellette County for settlement in 1910, although proclaimed in 1911, and "Bennett County was opened at about the same time" (Jennewein, 1961, 440).

By 1920, the PRR boundaries included extinct Washington, Shannon, and extinct Washabaugh Counties. In 1943, Washington County became a part of Shannon County (Thorndale and Dollarhide, 1987), taking effect in 1945 (Long, 1911). Finally, Washabaugh County became part of Jackson County in 1983 (Long, 2011). For purposes of this study, the boundaries for PRR include all of present-day Shannon and the southern part of Jackson Counties. However, in an ongoing dispute with the State of SD, tribal government often includes Bennett County, immediately south of Jackson County, as part of the Greater PRR.

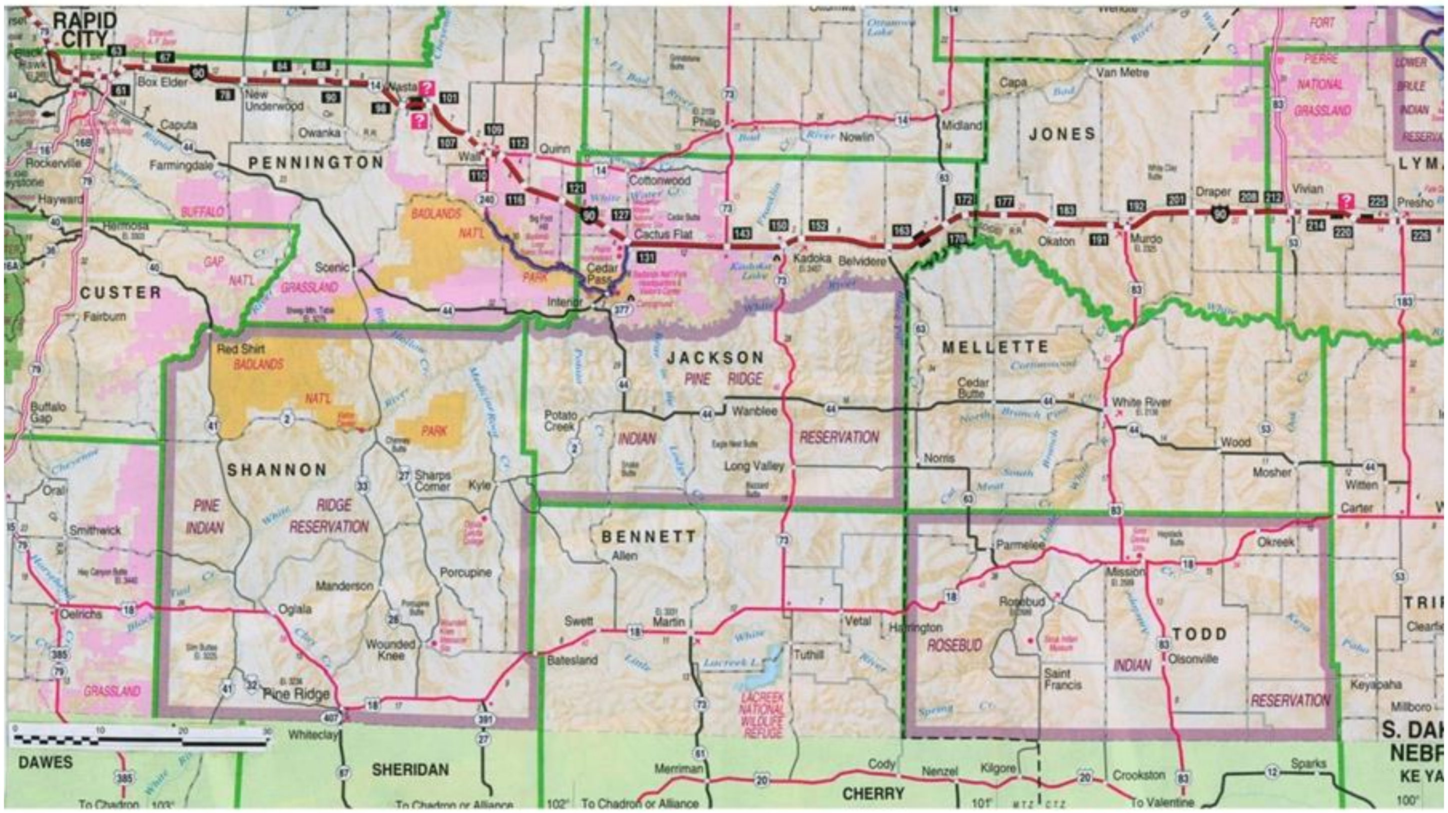


Figure 1. Rosebud and Pine Ridge Reservations from a segment of South Dakota Official Highway Map, 2011. South Dakota Department of Transportation (with permission, State of SD copyright.

LITERATURE REVIEW

In reviewing the literature about the plants of interest on PRR, I began with the current standard book reference for South Dakota, Theodore

Van Bruggen's *The Vascular Plants of South Dakota*, Third Edition (1996). The book was invaluable for identifying plants, but in it Van Bruggen also provided a succinct but detailed history of plant collectors in the state, beginning with the Lewis and Clark Expedition in 1804-1805 to William H. Over's 1932 classic book about the state's vascular plants, with its estimated 1,500 species (Over, 1932, after Van Bruggen, 1996). Van Bruggen also listed herbaria holding South Dakota plant collections, including these: SDSU; University of South Dakota, Vermillion; and Black Hills State College, among others in the state. For those known outside the state, he listed the Smithsonian Institution, University of Kansas, North Dakota State University, and the Missouri Botanical Garden (Van Bruggen, 1996). Since its publication, botanists updated many scientific plant names. Websites used as sources of contemporary scientific Latinized plant names, included the following: the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), "Plants Database," http://wwwplants.usda.gov (USDA, 2013); and The Biota of North America Program (BONAP), "North American Vascular Flora," http://www.bonap.org/ (BONAP, 2013).

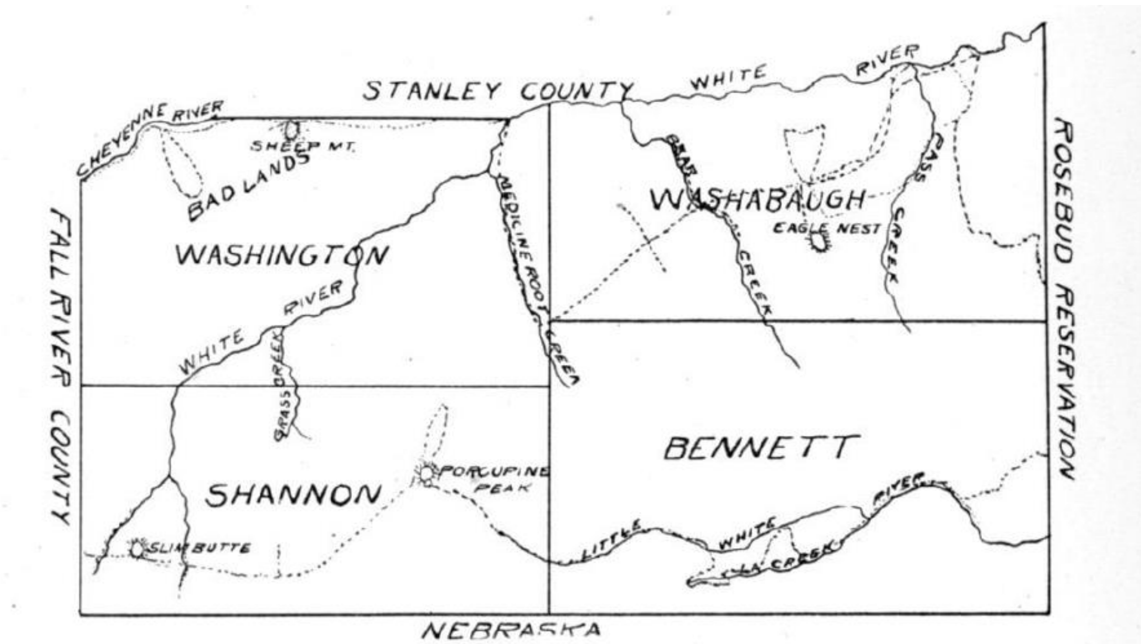
Books used to assist in field identification and to provide contextual information included *Grassland Plants of South Dakota and the Northern Great Plains* (Johnson and Larson, 2007) and *Plants of the Black Hills and Bear Lodge Mountains* (Larson and Johnson 2007). Others of interest included *Atlas of the Flora of the Great Plains* (Great

Plains Flora Association, 1977), *Trees of South Dakota* (Collins and Helwig, ca. 1972), *Plants of South Dakota Grasslands: A Photographic Study* (Johnson, 1970), and *Living Landscapes in South Dakota: A Guide to Native Plantscaping* (USDA NRCS, 2007).

STEPHEN SARGENT VISHER:
EARLY BOTANIST ON PINE RIDGE RESERVATION, 1911

Naturalist Stephen Sargent Visher of South Dakota's State Geological Survey, wrote that he collected an estimated 400 species of plants in southwestern South Dakota in the summer of 1911 (1912). About 90 were new to the state's list of plants known to scientists of the day. P. A. Rydberg of the New York Botanical Garden, provided sample specimen identifications for Visher, who published his findings in 1912 and 1913 (Visher, 1912; 1913a-c).

In State Geologist Ellwood C. Perisho's 1912 publication, Visher described his collection as "Plants of the Pine Ridge Reservation," which at that time included Bennett, Shannon, Washabaugh, and Washington Counties as shown in Figure 2 (1912, 109). The latter two counties are currently extinct, and Bennett County is not within the PRR boundaries. Throughout the 1912 and 1913 publications, Visher emphasized his discovering firsts for many plant species in the state. In his section of State Geologist Perisho's multi-topic publication, Visher noted that, "Neither the bad lands nor the sand hills of South Dakota had been botanically explored before, which is an explanation of the large number of species added to the [State of South Dakota's] flora"(1912, 45). Visher and Perisho mapped the locale, delineating the boundaries of Visher's botanical work as shown in Figures 2 and 3 (Visher, 1912; Perisho, 1908 and 1912).



A Sketch Map of the Old Pine Ridge Reservation

Figure 2. Visher's 1911 collection area and the Greater Pine Ridge Reservation. Lines indicate his trek with horses or on foot (Visher in Perisho 1912, 109-110). Washington County is extinct and merged with Shannon. Washabaugh is extinct and merged with Jackson. Bennett is not within borders of the PRR but is often included by locals within what is called the Greater PRR because the tribe owns some parcels of leased trust lands within the county. Courtesy of SDSU Archives & Special Collections, South Dakota State University, Brookings, SD.

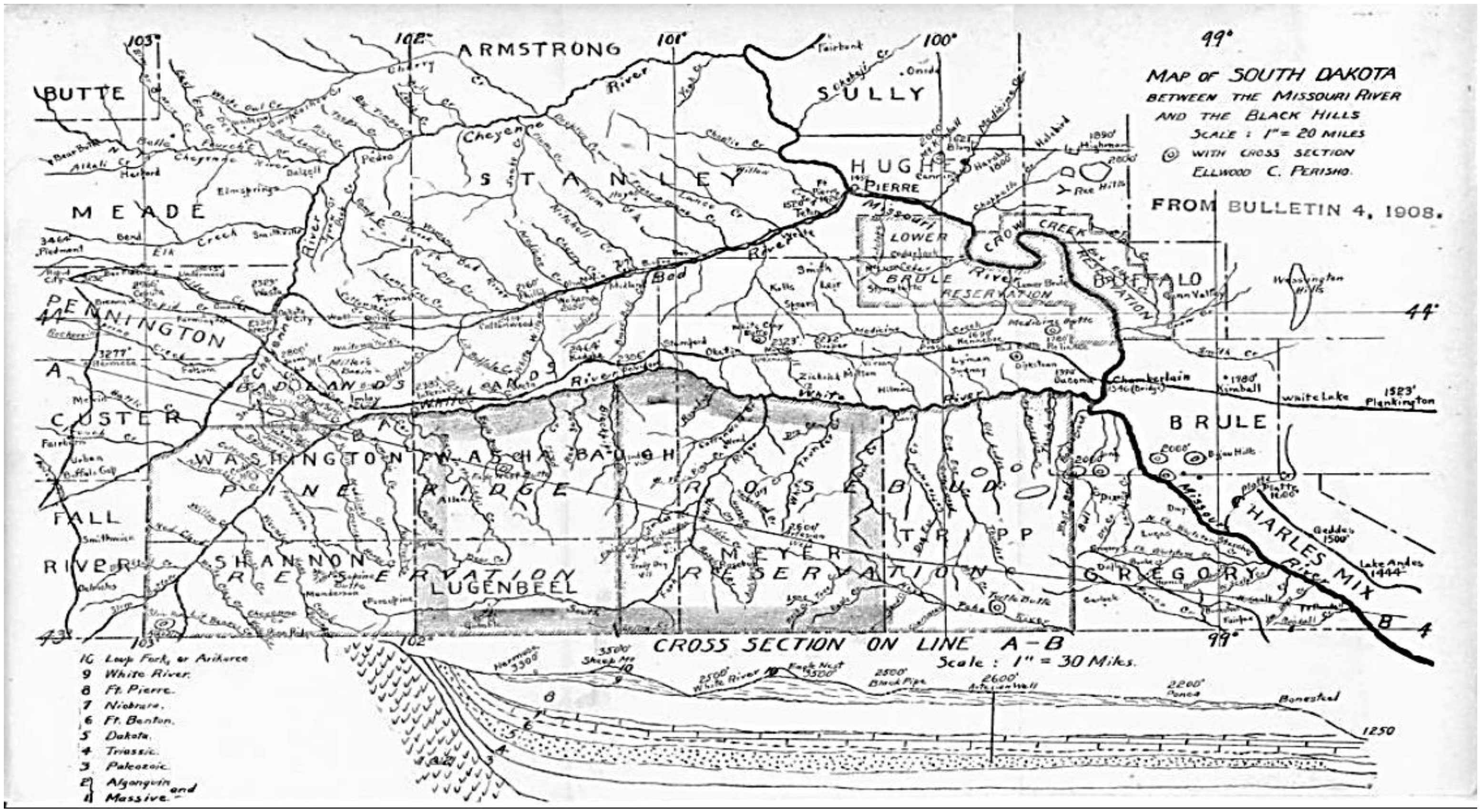


Figure 3. Perisho's map, 1908-1912, Pine Ridge and Rosebud Reservations (1908 and 1912, n.p.). County borders and names, and reservation boundaries changed through time. Not to original scale. Courtesy of SDSU Archives & Special Collections South Dakota State University, Brookings, SD.

Keeping in mind that the plants of interest in the current study are silver buffaloberry, buffalo currant, chokecherry, riverbank grape, wild plum, and wild roses, Visher reported the following concerning his 1911 expedition. Among the estimated 90 new species he added to the state's list, he found buffalo currant, *Ribes aureum* Pursh, (reported by Visher and formerly known as "*Ribes odoratum* Wendl.") and "*Rosa arkansana* Porter, Prairie rose," in Washington County. He collected "Wood rose" (formerly known as "*Rosa maximiliani* Nees.") in Washabaugh County, and "*Rosa suffulta* Greene" (regarded as a synonym of *Rosa arkansana*) in Bennett County (1912, 94-95; 1913c, 48).

In Visher's 1911 overall collection of plants, in the rose section, he reported neither prickly rose, *Rosa acicularis* L., nor smooth rose, *Rosa blanda* Ait.(1912), both of which I collected on the PRR in the current study, although sometimes in an apparently hybridized form. He reported riverbank grape, *Vitis riparia* Michx. as *Vitus volpina* L. in Washabaugh County (Visher, 1912, 99). He collected "Choke Cherry," *Prunus melanocarpa* (A. Nels.) Rydb. [*Prunus virginiana* L.], county not specified, and wild plum, *Prunus americana* Marsh., in Washabaugh County (Visher, 1912, 95). Thus, on Visher's 1911 expedition, he collected most of the plant species in this current study. It is important to note that from the Lakota perspective, local Indian populations knew and used all of these plants for centuries, although, no evidence showed that they distinguished between varieties of wild roses (Kindscher, 1992).

REVEREND EUGENE BUECHEL, S. J.: ETHNOBOTANY AND LANGUAGE STUDY—1917 TO 1923

Although not yet ordained as a Jesuit Roman Catholic priest, Eugene Buechel, (Fig. 4) immigrated to the United States from Europe in 1900, according to Dilwyn Rogers (1980a). Rogers also authored a book about plant uses of the region (1980b). Biographer Reverend Joseph Karol wrote that Buechel was born in Schleida, Thuringia, Germany in 1874 and studied for the priesthood in Germany and in Blyenback, Holland, where he entered the Jesuit order in 1897 (Karol, 1970). Buechel first collected and prepared plant vouchers and assembled ethnographic information, particularly in L dialect (Lakota) language, as a Christian missionary on the PRR (*Oglala* Lakota) and adjacent Rosebud Reservation (*Sicangu Oyate* also known as *Brule*) from 1917 to 1923. Whereas I collected all of the plants in the current study from PRR, Reverend Buechel only collected and vouchered a few plants there. He collected mostly from nearby Rosebud Reservation in present-day Todd County (Rogers, 1980a). His collection remains today on Rosebud Reservation at the local Buechel Memorial Lakota Museum at St. Francis, South Dakota. Buechel's other legacy, a dictionary, included local plant names and uses. He compiled thousands of entries from local residents, but he also included the work of Stephen R. Riggs, Emil Perrig, and Ella Cara Deloria, according to Marquette University's Raynor Memorial Libraries (2013). After Buechel's death in 1954, Reverend Paul Manhart, S. J. [Jesuit, Society of Jesus] edited Buechel's language study, entitled *A Dictionary of the Teton Dakota Sioux Language: Lakota-English: English-Lakota: With Consideration Given to Yankton and Santee Dialects* (Buechel, 1970 and 1983).

Dilwyn J. Rogers, a Professor of Biology at Augustana College in Sioux Falls, South Dakota, wrote Buechel's story and described his botanical collection in a book entitled *Lakota Names and Traditional Uses of Native Plants by Sicangu (Brule) People in the Rosebud Area, South Dakota: A Study on Father Eugene Buechel's Collection of Plants of Rosebud around 1920* (1980a). While still a seminary student, Buechel lived at St. Francis from 1902 to 1904 on Rosebud Reservation. After completing his studies at St. Louis University with ordination in 1906 (Karol, 1970), Buechel returned to South Dakota to Holy Rosary Mission at the village of Pine Ridge on PRR from 1907 to 1916 and again from 1926 to 1929. In the interim and during the remainder of his life, Buechel served as Superior to St. Francis Mission on the nearby Rosebud Reservation (Rogers, 1980a).

Figure 4. Reverend Eugene Buechel with unidentified Natives at Pine Ridge, SD, 1920s. Courtesy Buechel Memorial Lakota Museum Collection, St. Francis, South Dakota.

Buechel mostly collected plant specimens in the vicinity of St. Francis on Rosebud Reservation in present day Todd County, some from nearby Mellette County (non-reservation), and a few from extinct Washabaugh County on PRR (Rogers, 1980a). In addition, Buechel gathered limited data from native informants, mostly from Rosebud Reservation, concerning the uses of the plants for his *Lakota-English Dictionary* (Buechel, 1970; Rogers, 1980a). Rogers characterized Buechel's ethnobotanical work. Buechel corresponded with the famous anthropologist Franz Boas. Buechel determined the taxonomic, Latinized scientific names as best he could, in some cases with the help of the naturalist and museum director William H. Over of the University of South Dakota and from Paul C. Standley, Associate Curator of the Division of Plants, U. S. National Museum, Washington, D. C. In identifying plants, Buechel possibly accessed the three volumes of N. L. Britton and A. Brown's 1913, *An Illustrated Flora of the Northern United States* at St. Francis Mission School (Rogers, 1980a).

Dilwyn J. Rogers examined the plant collection, Buechel's notes, and the *Lakota-English Dictionary* as the basis for his book (1980a). He updated Buechel's scientific names, or lack thereof, based on Theodore Van Bruggen's 1976 book, *The Vascular Plants of South Dakota,* as well as M. R. Gilmore's 1919 book, *Uses of Plants by the Indians of the Missouri River Region*, 1977 edition (Rogers, 1980a). Rogers used parentheses for such updates and other added information in his book (1980a). Buechel reported 293 species in the collection, not counting duplicates, with 245 Lakota names. Buechel noted that 65 other species were named in the *Dictionary* but were not part of the plant collection. Concerning the Buechel collection as a whole, Rogers reported that "quite a few are fruits" (1980a, vi). Buechel included brief notes concerning "Family, Latin Name, Indian Name, Locality, Habitat, Date," and his signature on the specimen sheet labels according to Rogers (1980a, 108-110).

I summarized the plants of interest for the current study based on Rogers' analysis of both Buechel's plant collection and dictionary work (1980a), although pronunciation markings are omitted here. The Buechel collection included buffaloberry, buffalo currant, chokecherry, wild grape [riverbank grape], wild plum, and Woods' rose (Rogers, 1980a). As noted, specimen labels included Lakota names (as in Buechel's *Dictionary*) and some uses such as the following, after Rogers' analysis of Buechel's work. The brackets, below, replaced by commas in the original Rogers' text, indicate Rogers' commentary added to Buechel's work (Rogers, 1980a).

Buffaloberry, reported as "*mastinca pute can*. Means 'rabbit lip tree'. [Fruits are edible.]" (Buechel, 1970, 333; Rogers, 1980a, 44).

Buffalo currant, reported as "*wica gnaskahu*. Means 'male frog stem'. The fruits, *wicagnaska*, are edible. Stems are used for making arrows." Rogers noted that the Lakota name may have been for another species, *Ribes missouriense*-Gooseberry (1980a, 58).

Chokecherry, reported as "*canpa hu*. Means 'bitterwood stem'. Choke cherries, *canpa*, are edible; *canpakaski* refers to mashed, dried cherries; *canpasapa wi* is the month of July when the choke cherries are black ripe. The stems are used for arrows." (Buechel, 1970, 122; Rogers, 1980a, 57).

Wild grape, reported as *Vitis vulpina*, a separate species that ethnobotanists did not originally distinguish from *Vitis riparia*, was probably actually the latter, and was "*cunwi yapehe iyuwi*. Means 'wood used with wind around vine' or 'tangled vine'. [The fruits called *cunwiyapehe* are edible.]" (Buechel, 1970, 124; Rogers, 1980a., 61).

Plum, reported as "*kantahu can*. Means 'plum tree'. The fruits are edible. [*Kanta* is the plum. *Kantasa wi* means 'red plum moon'; this is the month of August when the plums are ripe."] (Buechel, 1970, 112; Rogers, 1980a, 56).

MELVIN R. GILMORE: ETHNOBOTANY AMONG THE LAKOTA

Melvin R. Gilmore collected early pioneering data about traditional plant uses among the Teton Lakota beginning in 1911-1912 (1913). He earned a Ph. D. in botany from the University of Nebraska in 1914. For his "thesis," he enlarged his study to include the Ponca and Pawnee of Nebraska and the Teton Lakota (Cutler 1991, x) of western Nebraska and southwestern South Dakota published in 1919 and posthumously in 1977 and 1991 (Gilmore, 1919, 1977, and 1991).

Gilmore reported that he showed actual plant specimens to those he interviewed to be certain that both he and his informants referred to the same plant. It seems unlikely that he produced plant specimen vouchers during his ethnographic or other botanical work, based on a recent database search by Thomas E. Labedz of the University of Nebraska State Museum's Bessey Herbarium (email from Labedz to Joanita Kant, July 24, 2013).

Gilmore collected ethnobotanical and linguistic information in Nebraska and South Dakota. His work included the Omaha, Ponca, Pawnee, Winnebago, and Sioux (1991, 40). Concerning the Sioux, Gilmore most often included information concerning the "Dakota," and he occasionally listed "Teton dialect," "Santee dialect," and "Yankton dialect" (1991, 68). When Gilmore referred to "the Dakota Nation" (1991, 9) it is uncertain whether he meant the entire Sioux nation, including all of the language dialects or if he simply meant D dialect speakers. Gilmore's charts, summarizing his work, only included "Dakota" words (1991, 103-111) and omitted the other dialects listed with each plant he described (1991, 68).

In the preface of Gilmore's thesis, he described his informants and his "own study of the languages" as follows.

> The information here collated has been obtained at first hand from intelligent and credible old persons, thoroughly conversant with the matters which they discussed. The various items have been rigorously checked by independent corroborative evidence from other individuals of the same tribe and of different tribes through a protracted period. The work of the interpreters employed has also been verified by comparison and by my own study of the languages of the various tribes interviewed (Gilmore, 1991, xvii).

Since Gilmore referred to the "Teton" in his preface, and thanked "Fast Horse and wife, Joseph Horncloud, Otto Chief Eagle, and Short Bull," identifying them as "Teton Dakota" (1919, 4; 1991, xviii), he likely collected information among L dialect speaking Lakota. Concerning the word "Teton," authors of *A New History of South Dakota,* (Thompson, General Editor, 2009, 44), noted that in older literature, "Teton sometimes was used to identify only Oglalas and Brules (the two southern Lakota tribes)… ." Possibly, Gilmore also used the term Teton to mean Oglalas and Brules.

Gilmore also referred to the "Dakota Nation" (1991, 9), possibly simply meaning all of the Sioux, or he could have meant only D dialect speakers, the eastern Sioux. Lakota is the language division for the western Sioux. The eastern and middle Sioux (Santee, Yankton, and Yanktonnais) speak D dialect Dakota. Despite the common historical lapse, probably begun by well-meaning missionaries, who referred to the

Yankton and Yanktonnais as N dialect speakers of Nakota, a dialect that likely never existed according to Parks and DeMaillie (1992, 1-4; 2001, 94-114).

The authors of *A New History of South Dakota* continue to list “Nakota” as a legitimate entity (Thompson, 2009, 44). Gilmore probably believed that the N dialect existed, since he included a “Yankton dialect” word for wild gooseberry (1991, 32). Thus, a dispute among experts concerning whether there were two dialects or three is far from settled.

Below, I compared some of Gilmore’s published data (1991) that included various Sioux dialects collected in 1911 and 1912 with that of Reverend Eugene Buechel’s that included mostly L dialect, collected beginning in 1917 and continuing into the early 1920s (Rogers 1980a). I omitted their pronunciation markings in the quotations for convenience.

For buffaloberry, Gilmore listed “mashtin cha-pute (Dakota)” meaning “rabbit nose” (1991, 54) rather than Buechel’s “mastinca pute can” meaning “rabbit lip tree” (Rogers, 1980a, 17, 44).

Gilmore noted that they ate buffaloberry raw or dried it for later use. Buffaloberry occasionally substituted for chokecherry, among the Dakota in a girl’s puberty ceremony (Gilmore, 1991, 36, 54).

Among plants used by the Dakota, Gilmore omitted buffalo currant.

Concerning chokecherry, Gilmore included a photo of a “Teton Dakota” woman pulverizing the fruits [drupes] for drying (1991, 32b). Gilmore recorded the Dakota word for chokecherry as “Chanpa” (1991, 36, 110); whereas, Buechel recorded the Lakota word as “canpa” (Rogers, 1980a, 57). In addition, Gilmore’s word for the month when chokecherries ripen differed from Buechel's. Chokecherries, Gilmore wrote, were highly prized by all tribes of the Missouri River region. Gilmore recorded that the Dakota and many tribes used them for "food . . . , old-time ceremonies and rituals as well as . . . stories, songs, and myths" (1991, 36). Gilmore noted that the natives travelled to their favorite spots where the cherries were plentiful. The natives pounded large quantities of chokecherries, pits and all, and formed them into small cakes to dry. The Dakota mixed the final product with dried meat to produce *wasna*, pemmican (Gilmore 1991, 36). Figure 5 shows the process.

Figure 5. Lakota Woman making chokecherry patties, ca. 1920s-1930s, Standing Rock Reservation. Denver Public Library, Western History Collection (catalogue number X-31710). Denver Public Library Digital Collections webpage. Used with permission <http://cdm16079.contentdm.oclc.org/cdm/singleitem/collection/p15330coll22/id/27221/rec/1>.

According to Gilmore, natives called wild grapes "*Hastanhanka* (Dakota); Teton dialect *Chan wiyape*," and the Teton version literally means "tree twiner." They ate wild grapes fresh or dried them for future use (1991, 50). Originally, botanists did not differentiate the two species of wild grapes in the region, but wild grapes in the locale of interest are all probably *Vitus riparia* Michx., not *Vitus vulpina* L., the species recorded by Gilmore.

The Dakota word for plum, Gilmore reported as "*Kante*" (1991, 35), rather than "*Kanta,*" Buechel's Lakota version (Rogers, 1980a, 56). Informants told Gilmore that they pitted the plums before they ate them freshly picked, cooked, or pounded and dried for future use. He also wrote that the Teton Dakota produced prayer wands using plum sprouts and branches. In a ceremony, the wand aided those interceding for the ill according to Dr. J. R. Walker, a Pine Ridge physician interviewed by Gilmore (1991, 35).

In addition, Gilmore recorded the name for wild rose (*Rosa spp.*) as "*onzinzhintka* (Dakota). *Onzhinzhintka-hu*, rosebush" (1991, 33). The only specific use for wild rose, attributed to the Dakota by Gilmore, was in a "Song of the Wild Rose," the translation of which Gilmore attributed to "Dr. A. McG. Beede" (1991, 33). The song lyrics described a time when a Dakota bride attached wild roses to her wedding dress and placed wild roses in her hair. In addition, the song celebrated Mother Earth's many songs including that of the wild rose (1991, 33-34).

OTHER AUTHORS

Of the plants of interest in this study, Kelly Kindscher recorded information about chokecherries and all the relevant wild roses among prairie tribes (1992, 189-193). He wrote that chokecherry was the "most important wild fruit to the Indians of the Prairie

Bioregion" including the Sioux (1992, 171, after Kindscher 1987, 177-182 [possibly after Gilmore 1991, 36]). Kindscher noted that Blankenship reported that the "Sioux" made tea from rose plant bark for intestinal ailments, and they masticated the dried roots to treat wounds and to control bleeding (Kindscher, 1992, 171; after Blankenship 1905, 19). Kindscher noted that wild roses frequently hybridize, and that there is no evidence to show that American Indians made distinctions between species (1992, 190), a reason I decided not to differentiate them in this study.

Daniel E. Moerman compiled all of the known uses of plants by Indians in America in a 927-page book entitled *Native American Ethnobotany* (1998) with a condensed version in 2010, *Native American Food Plants: An Ethnobotanical Dictionary*. Moerman included some of the plants in the current study, but I failed to find new information. While neither book helped in that regard, his books helped me to check for major gaps in my literature review.

S. K. Kraft' s 1990 M. S. thesis, a dietary study on the Standing Rock Reservation of northern South Dakota and southern North Dakota confirmed the frequency of Lakota participants' eating traditionally edible fruits in the modern day.

Morgan L. Ruelle and Karim-Aly S. Kassam (2011) confirmed the variety of opinions concerning plant knowledge among Elders on Standing Rock Reservation in northern South Dakota and southern North Dakota. The article was a good source of current information on the topic of modern Lakota ethnobotany, confirming that there was considerable diversity of opinions about the uses for traditional reservation plants (2011, 295-307).

Various authors compiled stories and legends that included traditionally edible plants among the Sioux. Examples included “The Story of a Hard Winter” in which a woman picked “rose berries” and gooseberries in the snow to keep from starving (South Dakota Writers’ Project 1987, 77), a story that reinforces the idea of rosehips as an emergency food. Another tale was “Maiden’s Isle,” in which a pelican brings fish and berries to a young woman stranded on an island (1987, 124). Other examples included “The White Fox,” a trickster who might steal buffaloberry jam (Yellow Robe 1979, 43).

RONALD L. MCGREGOR HERBARIUM COLLECTIONS, UNIVERSITY OF KANSAS: COLLECTORS ON PINE RIDGE RESERVATION FROM 1943-1974

Over the years, several persons collected plant specimens on and near PRR. The Ronald L. McGregor Herbarium at the University of Kansas in Lawrence, Kansas, has extensive collections of plants from the Great Plains, including PRR. Collection Manager Caleb A. Morse provided a list of relevant plants currently databased there, although he noted that there is no way to know how many of interest in their collections remain to be processed and databased (e-mail to author November 17, 2011). Morse sent their database records of collections from Bennett, Jackson, Shannon, and Washabaugh Counties at my request (Ronald L. McGregor Herbarium, 2011). Of 297 entries for individual plants, including locations, remarks, date collected, and collectors, 139 were probably from within the current boundaries of PRR. None of those from within the reservation boundaries included the plants of interest for this dissertation. However, other records of general interest included 70 entries for northern Jackson County and 88 in Bennett County, both outside the reservation boundaries. Their database showed that in

1970, Steve Stephens and Ralph E. Brooks collected buffalo currant (*Ribes aureum* var. *villosum* DC.) in Bennett County, just south of the PRR boundary, north of Allen, South Dakota. Buechel's name is not included as a collector of plants in their database (Ronald L. McGregor Herbarium, 2011).

HIGH PLAINS HERBARIUM COLLECTIONS, CHADRON STATE COLLEGE, CHADRON, NEBRASKA

The High Plains Herbarium at Chadron State College in Chadron, Nebraska contains close to 60,000 plant specimens. Steven Rolfsmeier, who recently succeeded the late Ronald Weedon as Curator of High Plains Herbarium, summarized their PRR holdings as follows:

> Our database shows about 110 specimen records from the Pine Ridge Reservation, with 27% of our collection entered. Our most prolific collectors (16-21 records apiece) are Claire Furman (1977), Lisa Smoke (1998) and Ronald Weedon (1978-1998). The next most prolific (6-13 apiece) are Dawn Holguin (1999), Frank Martinez (1976), Adedoyin Oduye (1974), Brandon Rock (1994) and Bill Tuma (1987). Other minor collectors were Joyce Hardy (1978), and Kyle Metzger (1987). We have 13 collections by J. Sipes (1969) and 7 by Fred Hagmann (1970) that are attributed to Shannon County, though most of Sipes collections were labeled simply "Pine Ridge" and were probably made in Nebraska, and some of Hagmann's localities are questionable too (E-mail Steven Rolfsmeier to author, September 11, 2013).

Within their current database, Rolfsmeier found only three specimens of the plants of interest for PRR, all in Shannon County, including buffalo currant, as "*Ribes odoratum*" [*Ribes aureum*] collected in 1998 by Lisa Smoke, and by Dawn Holguin, J. Holy Rock, and W. Mesteth in 1999. The latter three persons also collected buffaloberry, *Shepherdia argentea*, in 1999.

C.A. TAYLOR HERBARIUM AT SDSU AND OLC COLLECTIONS

Gary Larson, Curator of SDSU's C. A. Taylor Herbarium, reported that few plants from Pine Ridge Reservation were databased there. During the present study, I and student interns added voucher specimens of the plants of interest for their collections, and we provided duplicate copies for the newly established Oglala Lakota College (OLC) herbarium at *Piya Wiconi* campus near Kyle, South Dakota.

CYANIDE POISONING IN PLANTS OF INTEREST

Of the plants of interest in this study, some contain poisonous cyanide, particularly in the pits or achenes. Those include chokecherry, plum, and wild roses. John Kallas found that cyanide can be a concern, as follows.

> The body gets rid of cyanide by exhaling it from the lungs. Many plants you eat contain some cyanide. Eating small amounts is harmless because our body moves it to the lungs where you breathe it out. Ingest too much cyanide, however, and you overwhelm your lungs' ability to clear it, so it builds to harmful levels—harmful enough that it can kill you (2010, 40).

Dilwyn J. Rogers noted that while some plants, such as chokecherry, contain cyanide, "pounding and drying or cooking" render them harmless. He confirmed what has long been known, however, that cyanide-laden twigs and leaves of chokecherries can be poisonous to livestock (1980b 4, 90) David Ode recorded that cyanide, particularly common in the rose family and many others, "will poison livestock only if they are consumed in large amounts without prior exposure." In addition, Ode noted that "many animals can detoxify cyanide-containing compounds . . . if they consume small amounts of it over an extended period of time" (2006, 155).

METHODS AND MATERIALS

The interview instrument included both quantitative and qualitative, structured, and open-ended, pre-determined questions (Appendix B) in which paid informants participated in hour-long oral interviews. The use of quantitative questions helped to determine the estimated amounts and routes of exposure (ingestion and absorption) of the traditionally edible fruits of interest for use in Chapter 2 of the study. I asked participants to respond in quantities of "measuring cups" (one cup equals 240 mL or 0.23659 L by volume) as a handy common household unit of measure, after considering their advice about the best measurement to use.

B. L. Berg's spiraling qualitative research method undergirds the research, allowing flexibility, reassessment, and changes in a continuous process until developing a suitable research plan (2004). Thereby, I adapted methodological triangulation as central to the plan, whereby multiple lines of sight allowed a greater depth of understanding of the native perspective about the role of traditionally edible fruits in the modern day. Specifically, in the spiraling method, I determined the basic facts of the situation and then introduced more details, maintaining flexibility in a partnership with interviewees. Their opinions mattered, concerning the direction of the research, including ethical behavior and cultural sensitivities, particularly when discussions involved spiritual beliefs. The technique of triangulation of various perspectives added more depth of understanding by incorporating the variety of native viewpoints by asking each interviewee to tell me about traditionally edible fruits in their lives and by making their "stories" an integral part of the research.

Thus, my concern was how and why interviewees collected and used the fruits in the modern day. Further refinement, as proposed in Berg's methodological qualitative spiral (2004), resulted in the final qualitative question, "Do you have a related story that you want to tell?" (Appendix B). The literature review and a conversation with Cornelia White Feather, the first local informant, heavily influenced the adding of that final question. Those stories provided rich context for the role these fruits play in Lakota culture in the modern day. Their personal stories humanized the study, provided a particularly unique local viewpoint, and allowed unstructured native participation, where they added legacy information for future generations.

DATA COLLECTION

I conducted some interviews at St. Francis Mission guest house which served as field headquarters from August 20 to 26, 2012. Geraldine Provencial offered the use of the family's home and their food concession booth at the Rosebud Fair, where I conducted other interviews. In the process of data collection, I showed the participant the list of questions, asking for responses in that order (Appendix B) and recorded responses by typing them into a Word document on a personal computer, since most participants declined being tape recorded. I provided color photographs of the plants under discussion in case a participant was unsure of the identity of the plant in question. This rarely happened.

Concerning data collection, ethical boundaries existed for the study. As a part of the Institutional Review Board/ Reservation Review Board (IRB/RRB) process, NSF-supported Principal Investigator, Dr. Bruce Berdanier, and NSF-supported graduate student, Joanita Kant, obtained training and certification in the ethical treatment of human subjects through the National Institutes of Health (NIH), and/or through the Collaborative Institutional Training Initiative (CITI) subscription services providing on-line education.

Rosebud tribal government granted permission to conduct interviews and to collect stories, but all activities were wholly dependent upon permissions from their Reservation Review Board (RRB), facilitated by Elders serving on their Historical Preservation Commission. Rosebud tribal government required National Institute of Health (NIH) certification and standardized protocols prior to conducting research within their jurisdiction. As a result, I provided interviewees with documents explaining their rights. In addition, Rosebud tribal government's RRB and SDSU's IRB officers required detailed explanations of the proposed plan as shown in Appendix B. After receiving the necessary approvals, I conducted the interviews.

I requested permission to conduct oral interviews on PRR in 2012 and 2013, but at the time of this writing, the requests remained pending.

Interviewees on Rosebud Reservation signed and received copies of the following forms: Information Sheet and Consent Form (Appendix B), a W-9 Request for Taxpayer Identification Number and Certification, and a payment voucher from the South Dakota Humanities Council grant. The information sheet and consent form complied with the IRB/RRB and with general ethical concerns for studies of this type. Each interviewee received a 60 dollar check for their time and services, with funding provided by a grant from the South Dakota Humanities Council and administered by the South Dakota State University Foundation. I advised each interviewee that this study relates to my heavy metals analysis of traditionally edible fruits on PRR, including assays for arsenic, barium, lead, selenium, and uranium.

The Cultural Review Board's Elder Advisory Council for the Tribal Historic Preservation Office granted preliminary permission to use the interviews, acting for the Rosebud tribal RRB, through the efforts of Susie Blacksmith of the *Mni Wiconi* Program at Rosebud, SD. The Elders required a meeting where I explained the proposed project and required forms. Within a month of taking interviews, Rosebud Elders, acting for the Rosebud RRB, received an edited copy. They gave tentative approval but required that the entire dissertation, of which the interviews are a part, be subject to their review and approval before considering granting final permission to use the interviews.

Geraldine Provencial and Cornelia White Feather helped recruit participants. In addition, two interviewees served on the Elder Advisory Council for Tribal Historic Preservation, since they expressed interest when we met during the RRB process. They participated in those two interviews by telephone on September 12, 2012, and on October 4, 2012 by United States Postal Service mail; whereas, all others were face to face at various places on Rosebud Reservation in August 2012.

DATA PREPARATION AND ANALYSIS

Interviews numbered 32. I recorded participants' names, except for those who requested anonymity, and I extracted or estimated the ages of participants from the interviews. I recorded the quantity of each traditionally edible fruit and the intended use. In order to produce a final document (Appendix A), I edited interviews as soon as possible after collection. I searched the edited interviews and extracted data needed to meet the objectives of this study.

Of the 32 participants interviewed, 18 were women and 14 were men. Twenty-five per cent selected anonymity. Twenty-eight participants self-identified as enrolled members of the Rosebud. Others reported as follows: one Lakota at the Cheyenne River Reservation in South Dakota, one Santee Dakota enrolled in Nebraska, one Lakota who cannot obtain enrollment because she lacks the documentation, and a non-native who lives near the reservation in Nebraska but who is a life-long laborer on the Rosebud Reservation and who considers himself culturally integrated.

The estimated age in years of more than 78 per cent of those interviewed was from their 40s to their 60s with a mean of about 50 years. Five participants were in their 20s or 30s, 25 in their 40s, 50s, or 60s, and only two in their 70s or 80s. The age factor in the study was likely influenced by the method of attracting participants by word of mouth, probably creating the expectation that only those with significant interest and experience with traditionally edible fruits should come forward. As noted, results indicated that the subject of traditionally edible fruits was more important to the middle age and older participants rather than to the younger. The study also probably attracted fewer elderly participants (70s and older) because of the necessity of their travelling to a site where the interviews were being conducted, in most cases, possibly presenting a hardship. In recruiting participants, I obtained as wide a range of adult ages as circumstances allowed and tried to interview an equal number of each gender. The study was not meant to be a history, although interviewees consistently reported that their current uses of traditional fruits were affected by historical customs. During interviews, I often redirected the focus of participants to the uses of the plants in the present day.

RESULTS

PRESENCE AND AVAILABILITY OF FRUITS

I confirmed that the traditionally edible fruits selected for this study are widespread on both Rosebud and Pine Ridge Reservations where local residents continue to collect and to use them. The plants of interest grow wild throughout both reservations, and local residents commonly harvest them at no cost. The plants of interest are so widespread that I often viewed them from a truck while driving on paved highways throughout both reservations. All of the fruits grew sporadically in road ditches. Most often, I found all of the plants of interest along the edges of wooded draws, floodplains, rivers, creeks, and intermittent drainages. Wild roses grew in such settings, but wild roses also abundantly inhabited treeless badlands and pastures. Buffaloberries sometimes dotted the pasture landscapes or grew at a short distance from hardwoods fringed with chokecherry and plum bushes. Riverbank grapes clung to hardwoods and bushes, and they generally avoided growing in treeless grasslands lacking shrubs.

The plants of interest did not necessarily set fruit each year, influenced by the age, health, and gender of the plant (as in the case of buffaloberries), precipitation, weather, pollination problems, and destruction by cattle or deer. Interviewees reported that their families had secret places where they collected the best fruit, and the locations were not to be shared with others.

Interviewees reported that occasionally some raw fruits were sold at fairs, *wacipis* (dances), and other events. One interviewee sold bottled plum juice at the Rosebud Fair in 2012. One participant reported that Hutterites from eastern South Dakota traded chickens for permission to pick wild grapes on her land in the recent past. In their ethnobotanical study on Standing Rock Reservation, Ruelle and Kassam also reported that Hutterites came to the reservation to buy wild grapes (2011, 301). Several participants reported that they would buy traditionally edible fruit products in local grocery stores if they were available. One interviewee noted that she bartered in exchange for wild fruits. Thus, although limited, traditionally edible fruits are part of the economy in Lakota culture.

INGESTION, EXPOSURE, AND MODERN DAY USES

Participants reported consuming traditionally edible fruits by mouth either as food, beverage, tonic, or medicine—or some such combination—within the previous five years. Although some reported topical absorption exposures such as face painting or the dying of porcupine quills with the fruits in the past, no one reported such present day uses. Exposure to the fruits through skin absorption was reported as minimal. Their current skin exposure to the traditional fruits occurred when picking fruits and preparing them for immediate or later use. In addition, a few participants reported occasionally making small craft or religious items with peeled twigs and branches from chokecherry or plum bushes, but not often, and production was low. Those chokecherry branch items most often included frames for dream catcher wall hangings as shown in Figure 6 or, in one case, for pipe tampers and vision quest sticks. Some reported experiencing significant skin exposure to chokecherry plant juices, in particular, because the berries are often ground, formed into patties by hand, and dried for later use.

Figure 6. Scraped chokecherry branch wall-hanging produced by a Lakota craft worker and offered for sale at an outdoor craft booth near Wounded Knee, PRR, 2013.

Concerning amounts of ingestion, some participants collected and used all of the traditionally edible fruits in the study, while others use only a few. The most common use was simply for food, followed by beverage, medicine (spiritual or physical), and tonic (health supplement or disease preventative).

Interviewees estimated of amounts of each fruit they ingested, along with their uses as food, beverage, tonic, or medicine (Tables 1 through 6) in response to the question “How much, in measuring cups, would you estimate that you eat of each of the following traditionally edible fruits in one year’s time in an average year over the past five years.” I explained that I meant a year of sufficient rainfall in a year of good production of fruits. They reported that the fruits used the most were chokecherry and wild plum. Tables 1-6 indicate use by fruit type ranged from no use to 100 cups (23.66 L) per year of buffaloberry with an average of 2.77 cups (0.60 L), from no use to 100 cups (23.66 L) per year for buffalo currant with an average of 2.55 cups (0.60 L), from one to 150 (35.49 L) cups per year for chokecherry with an average of 16.88 cups (3.99 L), from no use to 80 cups (18.93 L) per year for riverbank grape with an average of 4.28 cups (1.01 L), from 0.50 cup (0.12 L) to 150 cups (35.49 L) per year for wild plum with an average of 15.28 cups (3.62 L), and from no use to 64 cups (15.14 L) per year for rosehips from wild roses with an average of 3.39 cups (0.80 L) (or much less frequently, as wild rose leaves for tea). There is such variation in the amounts of ingestion that it is more instructive to consider exposure on a case by case basis. The means, medians, and standard deviations, above, as shown in Tables 1 and 2 for buffaloberry and buffalo currant, respectively, do not include interviewee 18 as extreme outliers at 100 cups.

Table 1. Buffaloberry use by participant in cups in a good production year within the last five years. Key: * statistics not including No. 18, extreme outlier.

Participant Name	Number	Buffaloberry in Cups	in Liters	Used As
Cornelia White Feather	1	0	0	
Carole A. Provencial	2	0	0	
Byron Provencial	3	0	0	
Melvin Guerue	4	12	2.84	T
Anonymous	5	1	0.24	F
Michael White Buffalo Chief	6	2	0.48	FB
Anonymous	7	4	0.96	F
Sidney Reddest, Jr.	8	2	0.48	F
Leston Brewer	9	2	0.48	F
Keith Murray	10	5	1.18	F
Nicol Burow	11	0	0	
Maria Iyotte	12	0	0	
Leana Long Pumpkin	13	2	0.48	FB
Carol Black Elk	14	4	0.96	F
Nellie Eagleman Black Owl	15	2	0.48	F
Stanley Little Thunder	16	5	1.18	F
Sam High Crane	17	1	0.24	FM
Anonymous*	18	100	23.66	F
Anonymous	19	4	0.96	F
Anonymous	20	1	0.24	F
Altine Black Lance	21	5	1.18	F
Sylvan White Hat, Sr.	22	0	0	
Anonymous	23	0	0	
Larry Black Lance	24	1	0.24	F
Aloysius Running Horse	25	1	0.24	F
Clayton High Pipe	26	3	0.71	F
Greg P. Quigley	27	16	3.79	TM
Anonymous	28	0	0	
Audrey Bear Dog	29	4	0.96	FBTM
Anonymous	30	8	1.89	F
Delores Kills In Water	31	0	0	
Violet Little Elk	32	1	0.24	F
mean*		2.77	0.66	
median*		2.00	0.48	
standard deviation*		3.59	0.85	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 2. Buffalo currant use by participant in cups in a good production year within the last five years. Key: * statistics not including No. 18, extreme outlier.

Participant Name	Number	Buffalo Currant in Cups	in Liters	Used As
Cornelia White Feather	1	2.00	0.48	F
Carole A. Provencial	2	0.00	0.00	
Byron Provencial	3	2.00	0.48	F
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	1.00	0.24	F
Michael White Buffalo Chief	6	2.00	0.48	FB
Anonymous	7	6.00	1.44	FM
Sidney Reddest, Jr.	8	3.00	0.72	F
Leston Brewer	9	0.00	0.00	
Keith Murray	10	5.00	1.18	F
Nicol Burow	11	0.00	0.00	
Maria Iyotte	12	4.00	0.96	FB
Leana Long Pumpkin	13	2.00	0.48	F
Carol Black Elk	14	4.00	0.95	F
Nellie Eagleman Black Owl	15	1.00	0.24	F
Stanley Little Thunder	16	2.00	0.48	F
Sam High Crane	17	4.00	0.95	FM
Anonymous*	18	100.00	23.66	F
Anonymous	19	0.00	0.00	
Anonymous	20	0.00	0.00	
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	0.00	0.00	
Anonymous	23	0.00	0.00	
Larry Black Lance	24	0.00	0.00	
Aloysius Running Horse	25	1.00	0.24	F
Clayton High Pipe	26	0.00	0.00	
Greg P. Quigley	27	4.00	0.96	TM
Anonymous	28	0.00	0.00	
Audrey Bear Dog	29	8.00	1.89	FBTM
Anonymous	30	16.00	3.79	F
Delores Kills In Water	31	0.00	0.00	
Violet Little Elk	32	1.00	0.24	F
mean*		2.55	1.36	
median*		2.00	0.48	
standard deviation*		3.30	4.14	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 3. Chokecherry use by participant in cups in a good production year within the last five years.

Participant Name	Number	Chokecherry in Cups	in Liters	Used As
Cornelia White Feather	1	5.00	1.18	F
Carole A. Provencial	2	8.00	1.89	F
Byron Provencial	3	12.00	2.84	F
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	10.00	2.37	FB
Michael White Buffalo Chief	6	3.00	0.71	FBM
Anonymous	7	12.00	2.84	FBM
Sidney Reddest, Jr.	8	12.00	2.84	F
Leston Brewer	9	2.00	0.48	F
Keith Murray	10	9.00	2.13	F
Nicol Burow	11	2.00	0.48	F
Maria Iyotte	12	2.00	0.48	FB
Leana Long Pumpkin	13	80.00	18.93	FBTM
Carol Black Elk	14	2.00	0.48	FBM
Nellie Eagleman Black Owl	15	2.00	0.48	FB
Stanley Little Thunder	16	5.00	1.18	FB
Sam High Crane	17	6.00	1.42	FBM
Anonymous	18	16.00	3.79	F
Anonymous	19	8.00	1.89	F
Anonymous	20	8.00	1.89	F
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	6.00	1.42	F
Anonymous	23	5.00	1.18	F
Larry Black Lance	24	1.00	0.24	FM
Aloysius Running Horse	25	30.00	7.10	FB
Clayton High Pipe	26	16.00	3.79	FM
Greg P. Quigley	27	16.00	3.79	TM
Anonymous	28	150.00	35.49	F
Audrey Bear Dog	29	80.00	18.93	FBTM
Anonymous	30	16.00	3.79	F
Delores Kills In Water	31	4.00	0.95	FB
Violet Little Elk	32	1.00	0.24	F
mean		16.88	3.99	
median		7.00	1.66	
standard deviation		30.19	7.14	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 4. Riverbank grape use by participant in cups in a good production year within the last five years.

Participant Name	Number	R. Grape in Cups	in Liters	Used As
Cornelia White Feather	1	5.00	1.18	F
Carole A. Provencial	2	1.00	0.24	F
Byron Provencial	3	0.00	0.00	
Melvin Guerue	4	6.00	1.42	FT
Anonymous	5	1.00	0.24	F
Michael White Buffalo Chief	6	4.00	0.95	F
Anonymous	7	5.00	1.18	FB
Sidney Reddest, Jr.	8	0.50	0.12	F
Leston Brewer	9	2.00	0.48	FB
Keith Murray	10	2.00	0.48	F
Nicol Burow	11	0.00	0.00	
Maria Iyotte	12	0.00	0.00	
Leana Long Pumpkin	13	80.00	18.93	F
Carol Black Elk	14	2.00	0.48	F
Nellie Eagleman Black Owl	15	0.00	0.00	
Stanley Little Thunder	16	2.00	0.48	FB
Sam High Crane	17	0.50	0.12	FM
Anonymous	18	0.00	0.00	
Anonymous	19	0.00	0.00	
Anonymous	20	0.00	0.00	
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	0.00	0.00	
Anonymous	23	0.00	0.00	
Larry Black Lance	24	1.00	0.24	F
Aloysius Running Horse	25	0.00	0.00	
Clayton High Pipe	26	1.00	0.24	FM
Greg P. Quigley	27	0.00	0.00	TM
Anonymous	28	0.00	0.00	
Audrey Bear Dog	29	16.00	3.79	F
Anonymous	30	2.00	0.48	F
Delores Kills In Water	31	0.00	0.00	
Violet Little Elk	32	1.00	0.24	F
mean		4.28	1.01	
median		1.00	0.24	
standard deviation		13.94	3.30	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 5. Wild plum use by participant in cups in a good production year within the last five years.

Participant Name	Number	Wild Plum in Cups	in Liters	Used As
Cornelia White Feather	1	5.00	1.18	F
Carole A. Provencial	2	4.00	0.95	F
Byron Provencial	3	6.00	1.42	F
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	4.00	0.95	FM
Michael White Buffalo Chief	6	10.00	2.37	FBM
Anonymous	7	12.00	2.84	FM
Sidney Reddest, Jr.	8	6.00	1.42	F
Leston Brewer	9	1.50	0.35	F
Keith Murray	10	0.50	0.12	F
Nicol Burow	11	1.00	0.24	F
Maria Iyotte	12	4.00	0.95	F
Leana Long Pumpkin	13	16.00	3.79	F
Carol Black Elk	14	1.00	0.24	F
Nellie Eagleman Black Owl	15	3.00	0.71	B
Stanley Little Thunder	16	4.00	0.95	F
Sam High Crane	17	12.00	2.84	FM
Anonymous	18	80.00	18.93	F
Anonymous	19	8.00	1.89	F
Anonymous	20	3.00	0.71	F
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	6.00	1.42	F
Anonymous	23	5.00	1.18	F
Larry Black Lance	24	3.00	0.71	F
Aloysius Running Horse	25	30.00	7.10	F
Clayton High Pipe	26	10.00	2.37	FM
Greg P. Quigley	27	32.00	7.57	TM
Anonymous	28	150.00	35.49	FBM
Audrey Bear Dog	29	32.00	7.57	F
Anonymous	30	16.00	3.79	F
Delores Kills In Water	31	12.00	2.84	F
Violet Little Elk	32	1.00	0.24	F
mean		15.28	3.62	
median		6.00	1.42	
standard deviation		28.45	6.73	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 6. Wild rose use by participant in cups a good production year within the last five years. Most often rosehips were used, but, occasionally, leaves were used for tea.

Participant Name	Number	Wild Rose in Cups	in Liters	Used As
Cornelia White Feather	1	0.00	0.00	
Carole A. Provencial	2	0.00	0.00	
Byron Provencial	3	0.00	0.00	
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	2.00	0.47	B
Michael White Buffalo Chief	6	1.00	0.24	FB
Anonymous	7	2.00	0.48	B
Sidney Reddest, Jr.	8	0.00	0.00	
Leston Brewer	9	0.00	0.00	
Keith Murray	10	0.00	0.00	
Nicol Burow	11	0.00	0.00	
Maria Iyotte	12	0.00	0.00	
Leana Long Pumpkin	13	2.00	0.47	BTM
Carol Black Elk	14	2.00	0.47	BM
Nellie Eagleman Black Owl	15	2.00	0.47	F
Stanley Little Thunder	16	0.00	0.00	
Sam High Crane	17	0.00	0.00	
Anonymous	18	16.00	3.79	F
Anonymous	19	0.00	0.00	
Anonymous	20	0.00	0.00	
Altine Black Lance	21	10.00	2.37	B
Sylvan White Hat, Sr.	22	0.00	0.00	
Anonymous	23	0.00	0.00	
Larry Black Lance	24	0.00	0.00	
Aloysius Running Horse	25	0.00	0.00	
Clayton High Pipe	26	0.50	0.12	T
Greg P. Quigley	27	64.00	15.14	TM
Anonymous	28	1.00	0.24	B
Audrey Bear Dog	29	0.00	0.00	
Anonymous	30	0.00	0.00	FB
Delores Kills In Water	31	0.00	0.00	
Violet Little Elk	32	0.00	0.00	
mean		3.39	0.80	
median		0.00	0.00	
standard deviation		11.38	2.69	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Participants stated that, generally, they ate more fruit at the time of harvest in mid-summer and early fall when fruit was freshly picked. The majority of participants consumed the fruits year round, however, since it is often dried, frozen, or canned for later use.

They reported not eating ground plum pits, and they usually discarded the achenes (seeds) of rosehips, as well. Concerning the other fruits of interest, they reported sometimes grinding the pits, seeds, and achenes and including them in the dish being prepared, although occasionally they strained and discarded them. In the case of chokecherries, except when eaten raw during harvesting, they often ground the pits during preparation, giving the food a gritty texture, but more flavor. Others reported discarding the chokecherry pits when preparing food and beverages.

Participants reported using the fresh fruits raw, as well as frozen or dried. The various types of uses included a pudding (*wojapi*), a type of trail mix or side dish or pemmican (wet or dry *wasna*), jam, jelly, syrup, juice, candy, popsicles, and rose tea. Some made or consumed rose tea made only from water and tea leaves and others made from rosehips. In addition, they made and used various medicines or tonics from all the fruits. Interviewees reported the final forms of the products made from traditionally edible fruit plants in the past five years on Rosebud Reservation (Table 7).

Table 7. Forms of final product used on Rosebud Reservation.

Plant Common Name	Forms of Final Product
buffaloberry	raw, *wasna, wojapi,* jam, jelly, and juice
buffalo currant	raw, *wasna, wojapi,* jam, jellly, juice, twigs for crafts, and story
chokecherry	raw, *wasna* , *wojapi* , jam, jelly, juice, syrup, dried snack, taffy, lotion for poison treatment, twigs for the following: crafts, pipe tampers, and religious ceremonies
riverbank grape	raw, *wojapi* , juice, syrup, wine, and popsicles
wild plum	raw, *wasna* , *wojapi* , jam, jelly, syrup, plum buttter, dried fruit addition to roasting meat
wild rose	Rosehips as follows: raw, *wojapi* , jelly, juice, tea, and addition to roasting meat, powdered for poison ivy treatment; twigs for crafts; leaves for tea; entire plant for stories

CULTURAL IMPORTANCE

The interviewees on Rosebud Reservation indicated that traditionally edible fruits remain an important part of cultural life. Among interviewees, the percentages of those using buffaloberry, buffalo currant, chokecherry, riverbank grape, wild plum, and rosehips or rose leaves, respectively, were 72, 66, 100, 59, 100, and 37. Participants often reported the collection, preparation, and use of traditionally edible fruits as important for cultural identity, on a par with Lakota language and Lakota spirituality. The majority of those interviewed reported an obligation to pass on these practices to the next generation. Results showed that traditionally edible fruits and certain plant parts remained a part of Lakota folklore, storytelling, and rituals, and their use happily reminded many of their younger years and their ancestors. Most of those interviewed noted that traditionally edible fruits play a key role in cultural cohesion and in the embeddedness of Lakota spiritual life. They reported the fruits used at spiritual, healing, and naming ceremonies; funerals and wakes; and at dinners and meetings where important decisions were made. In addition, many used the fruits to honor the Elders, to cure ailments, to improve health, or to share as reciprocal gifts.

DISCUSSION AND CONCLUSIONS

The interviews from Rosebud Reservation provided new information about the continued presence and availability of traditionally edible fruits there. While traditionally edible fruits and their plant parts constituted a valuable resource among the Lakota in the past, the present study provided details concerning the fruits' importance in Lakota culture in the modern day. Although participants did not report the fruits of interest as a main staple of their daily diets, results indicated that considerable gathering and using of the plants of interest continues, although less so than in the last century. S. K. Kraft confirmed, in a 1990 M. S. thesis for the University of North Dakota, that the fruits did not constitute a staple of the daily diet in research among the Lakota on Standing Rock Reservation.

Generally, the older participants on Rosebud Reservation reported more interest and more usage than those younger, although results showed that the fruits are not a major component of the daily diet for most participants of any age. Most reported that they expected the fruits to be served at important events, particularly at wakes, funerals, and spiritual ceremonies. The most ingestion occurred around harvest time in July and August, although they generally reported eating dried, frozen, and canned fruits throughout the year. They reported the fruits and plant parts as intertwined with Lakota spirituality and identity, describing specific uses as foods, beverages, medicines, and tonics, with limited uses for crafts, utilitarian, and religious paraphernalia. I found considerable diversity in opinions about the general topic of traditionally edible fruits on Rosebud Reservation. That finding confirmed trends reported by Morgan L. Ruelle and Karim-Aly S. Kassam in their ethnobotanical research among the Lakota on Standing Rock Reservation (2011, 295-307).

Interviewees estimated the amounts ingested for each of the fruits of interest as highly variable from individual to individual, in the most extreme cases, by as much as 145.5 cups (34.42 L) per year for some fruits of interest. From interviewee data, I estimated exposure levels to certain estimated heavy metals concentrations detected in traditionally edible fruit and plant samples from nearby PRR, the focus of Chapter 2.

RECOMMENDED FUTURE RESEARCH

Since results indicated that traditionally edible fruits do not constitute a major component of the daily diet for most of those interviewed on Rosebud Reservation, I recommend total dietary studies in the future. Such studies may provide a more accurate estimation of heavy metals exposure through diet, in light of pockets of elevated heavy metals levels in plants and the soils in which they grow on nearby PRR.

Researchers might consider investigating the potential for economic development of traditionally edible fruits, since interviewees reported them as a valuable commodity with limited current sales or bartering. Furthermore, interviewees indicated a desire to purchase such products if available.

CHAPTER 2: HEAVY METALS ON PINE RIDGE RESERVATION

INTRODUCTION

Pine Ridge Reservation residents expressed concern about heavy metals because they live in a locale where levels are naturally high, particularly for uranium and selenium. Heavy metals selected for the study included arsenic (As), barium (Ba), lead (Pb), selenium (Se), and uranium (U), since they were of particular interest to the Oglala Lakota Sioux Tribe's Natural Resources Regulatory Agency (OST NRRA). Residents were especially interested in this study to help build a database of preliminary baselines for soils and plants on the reservation to help manage their resources. While they were aware of some soil and plant baselines for heavy metals for the conterminous United States, the OST NRRA sought more detailed information from samples unique to PRR. As Gustavsson et al. (2001) noted, soil sampling databases and geochemical mapping are important tools in detecting geochemical variations, anthropogenic disturbances, mineral deposits that might be extracted, and potential health effects, among others. The United States Centers for Disease Control (US CDC) and the United States Environmental Protection Agency (US EPA), as well as others, provide heavy metals standards to help assess potential toxicity in edible plants. The US CDC reports that oral intake standards help professional health risk managers to assess "where to look more closely" (US CDC, 2013 b).

The scientific community lacks a commonly agreed upon definition for the phrase "heavy metals," but the phrase is widely used, in the medical sense, to refer to a variety of elements and their compounds that have the potential for toxicity in humans and animals. Writers of both popular and scientific literature often use the term in referring to elements that may be neither metals nor heavy in terms of density, atomic weight, and number.

HYPOTHESIS

The hypothesis of this study is that modern use of traditionally edible fruits by the Lakota increases their risk of exposure to certain heavy metals, potentially to the point of toxicity (as stated in Chapter 1).

OBJECTIVES

1. Produce preliminary baseline concentration levels of selected heavy metals in certain traditionally edible wild fruits and the soils in which they grow, on (PRR) in a screening study.
2. Compare and contrast observed concentration levels in traditionally edible fruits with a variety of heavy metals standards, guidance, and risk assessments.
3. Determine if ingestion or absorption of traditionally edible fruits increases human exposure to heavy metals to the point of potential toxicity, using exposure data collected in Chapter 1.

BACKGROUND

The background includes (1) concerns about possible uranium contamination among some local residents of PRR and (2) boundaries and geography for the study. The literature review includes (3) other heavy metals studies in soils and sediments in South

Dakota; (4) overviews of the heavy metals of interest; (5) an overview of spectrometry as a common technique for analyses of elements in foods; (6) general health effects of heavy metals toxicity; and (7) selected standards, guidance, and risks assessments for heavy metals in foods and the soils in which they grow.

CONCERNS OF PINE RIDGE RESERVATION RESIDENTS

The Oglala Lakota Sioux Tribe's government is well-aware that the reservation is a locale with high levels of certain heavy metals, particularly uranium and selenium. There has long been concern about the safety of nearby uranium mining among residents of PRR. Uranium is or was extracted in two counties adjacent to the reservation on the west and south. In the 1970s, uranium was mined in Fall River County, SD, and there are current plans to resume operations there. In addition, for over 20 years, Crow Butte uranium mine has operated in bordering Dawes County, Nebraska, near the small town of Crawford. Both mine locations are upstream from the Cheyenne and White Rivers, respectively, that border or flow through the reservation from southwest to northeast, raising the issues of potential surface and groundwater contamination, in particular.

Nebraska Public Broadcasting's Net Radio news caster Fred Knapp reported both sides of the uranium issue on July 7, 2011. Ken Vaughn, who represented Cameco, a Canadian company that owns the Crow Butte mine, assured listeners that the mine operated safely with its injection well technology and land restoration activities. A critic of the mine, geologist Hannan LaGarry, expressed skepticism when interviewed by Knapp. LaGarry, then head of the Math and Science department at the tribally controlled Oglala Lakota College on PRR, expressed concerns about Crow Butte mine safety as follows:

> 'They're forcing oxygenated water down into the ground to force a chemical reaction that wouldn't normally occur . . . and in the process freeing trapped accessory minerals that co-occur with the uranium. And then this becomes a heavy-metal laden soup.
>
> . . . Eventually, it's likely that there will be communication of mining fluids outside of their mining area . . . . There could be what's called an excursion outside their monitoring wells and potentially contaminate the overlying surficial deposits (and) the White River.'

Thus, there is disagreement concerning whether or not uranium mining poses a contamination risk in the locale.

Concern about uranium among residents of PRR is fueled by recent newspaper articles in the Rapid City Journal (2013a and 2013b) and the Sioux Falls Argus Leader (2013). Powertech, a mining company, requested a state permit to mine uranium near Edgemont, SD, in Fall River County, bordering PRR on the west. Lilias Jarding of Rapid City of the grassroots environmental organization, Clean Water Alliance, has been a vocal critic of uranium mining in both Nebraska and South Dakota.

Also drawing attention to the subject of uranium on PRR is the movie *Thunderheart*, produced in 1992 and still available for viewing. The film was shot partially on-location on PRR. The movie kept the uranium issue brewing with its fictionalized story in which residents fought against a conspiracy to harm the reservation through uranium poisoning. Thus, uranium has been viewed by some residents of PRR as an uncertain, potential threat for decades.

In addition, PRR has a history of long-standing concern about potential chemical residue on a World War II era conventional weapons bombing range in the northwest quarter of PRR shown on the maps in Figures 7 and 15. Known locally as the "Bombing Range," it was a place where United States military aircraft conducted practice bombing runs with wrecked car bodies as targets. A road sign at "Bombing Range Road," east of the village of Potato Creek, remains as a daily reminder of 1940s Department of Defense activities on the gunnery range (Fig. 8).

In 1998, Mike Lambert of the Hazardous Substances Research Center evaluated potential toxicity of uranium and selenium on the gunnery range on PRR. Lambert's evaluation was part of Technical Outreach Services to Native American Communities (TOSNAC), a program based on unbiased evaluations presented to native communities concerning activities at former Department of Defense sites (Lambert, 1998).

More recent research suggests that even low levels of naturally occurring uranium can pose health risks. At the time of Lambert's report, he noted that the highest concentration of "natural uranium" in soils in "southern South Dakota" was 11 ppm in 1998 (probably after Shacklette and Boerngen, 1984). However, the current study indicated the highest concentration of uranium in soils for PRR at 35.94 ppm at Site 8 near Potato Creek village along the southeast border of the former US military gunnery range on PRR.

Lambert compared uranium concentrations of 11 ppm, as above, to 230 ppm from the US EPA Region III's Risk-Based Concentration (RBC) "table [that] sets a limit of uranium in residential soil of 230 ppm" (Lambert, 1998). The RBCs in Lambert's report were predecessors of today's US EPA Regional Screening Levels (RSLs), also known as Preliminary Remediation Goals (PRGs) (Hubbard, 2008). RBCs or PRGs are not meant as stand-alone levels that imply safety. They are, instead, only a first step in clean-up efforts at anthropogenically caused pollution at Superfund Sites or should be used to assess sites not yet on the National Priorities List for Superfund Sites. If naturally occurring background levels exceed PRGs, clean-up is not undertaken at Superfund Sites (US EPA, 2012). Thus far, there is no scientific evidence to show that heavy metals levels on PRR are other than naturally occurring in soils; however uranium concentrations in soils on PRR in the current study are higher than those cited by Lambert.

Lambert (1998) reported that selenium was not a component used in manufacturing conventional bombs during the active period of the gunnery range. He concluded that selenium does not pose a health risk on the bombing range, with the exception of naturally occurring selenium in livestock forage. In particular, Lambert identified loco weed, goldenweed, and prince’s plume as plants naturally high in selenium.

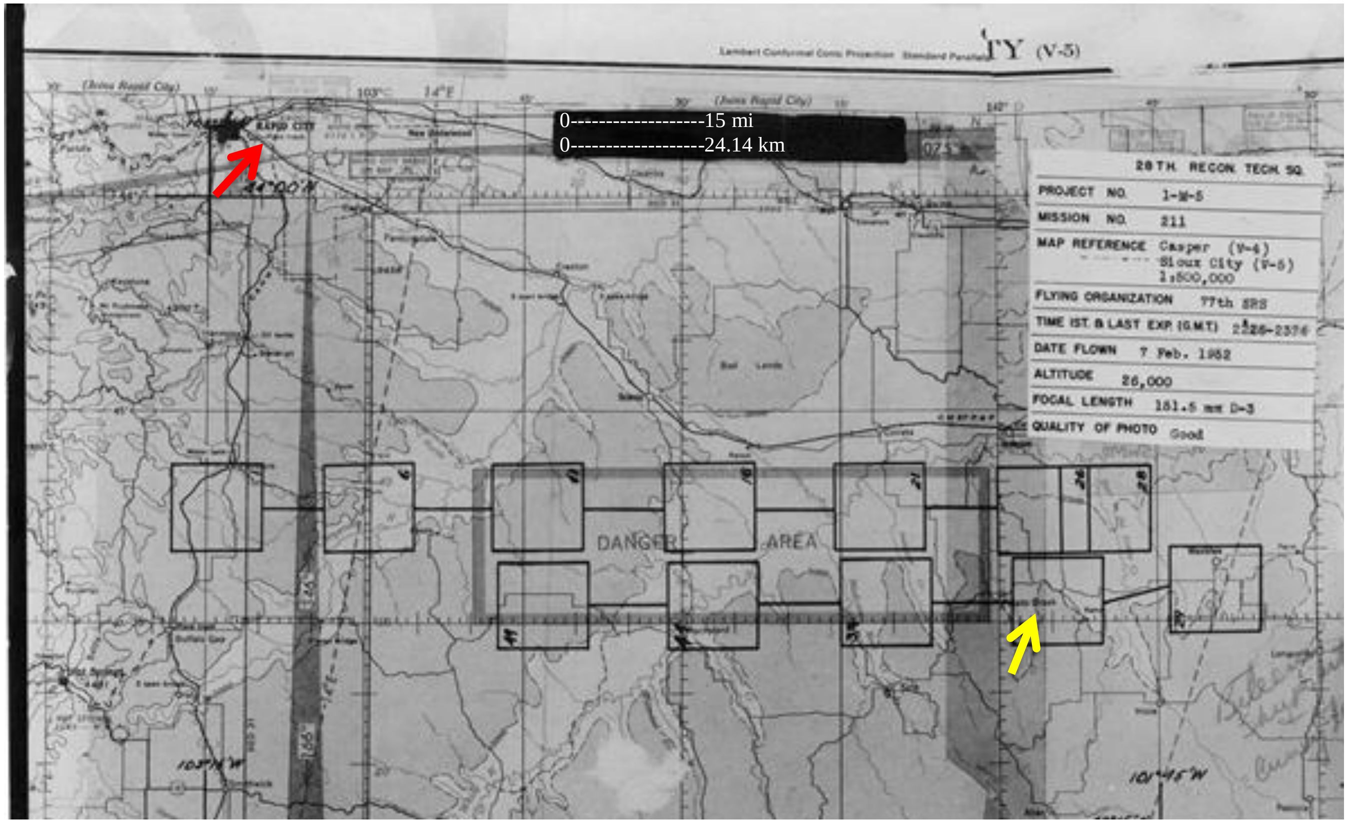


Figure 7. World War II gunnery range map, Department of Defense, 1952. While its borders extended beyond the west border of PRR, within reservation borders, it extended roughly north and west of the village of Potato Creek, SD (modified after South Dakota State Archives, Pierre, SD). Rapid City is marked with a red arrow and Potato Creek village with a yellow arrow. Borders of the gunnery range are shown in Figure 15 in the context of the entire study area. Scale of miles added.

Figure 8. Bombing Range Road sign on PRR, named for the World War II era US Department of Defense bombing range test site.

The heavy metals of interest in this study, arsenic, selenium, lead, barium, and uranium, were of particular interest to the Oglala Sioux Tribe, including Director Michael Catches Enemy and associate Kathryn Converse of the tribe's NRRA in 2011 when this study began. They were in the process of building a database from which to manage the environment. They encouraged my research and provided a letter of endorsement and introduction.

BOUNDARIES AND GEOGRAPHY OF THE STUDY AREA

The study area, PRR, home of the Oglala Lakota, is in Shannon County and the southern half of Jackson County on the Great Plains of southwestern South Dakota (Fig. 9). As part of the larger Missouri Plateau in western South Dakota, Shannon County is further subdivided into the Southern Plateau with the Pierre Hills along the western border. Southern Jackson County is wholly classified as Southern Plateau (Hogan and Fouberg, 2001; after Flint, 1955). Hogan and Fouberg have described the Southern Plateau as follows:

> This area is comprised of young rock formed by the debris produced by the erosion of the Black Hills and Rocky Mountains and carried eastward by wind and water. Today, this is a region of wide, flat areas of land between streams and contrasting deep, narrow stream valleys and canyons. It is also a region of badlands, buttes, and tables. The Southern Plateaus are dominated by rocks formed from sands and clays, occurring in a variety of colors. Streams have cut deep into the landscape, exposing the sub-surface rocks.
>
> The northern part of the Southern Plateaus is noted for its badlands topography. Of the several badlands areas found here, the largest and most famous is the Big Badlands, which follow the White River for over 100 miles. . . . Badlands result from a combination of geologic and climatic factors: falling and running water; the sands, clay and volcanic ash that form the soil and rock materials; and elevation that results in rapid downcutting by streams.
>
> The bulk of the land in the northern part of this subregion is composed of level plains. The land is today covered with grasses or is farmed. . . .
>
> The southern section of the subregion is locally known as the "Tables." It is comprised of large, wide-topped buttes and mesas. Among the more notable tables are Cuny Table, Sheep Mountain Table, and Hart Table. They stand over 400 feet above the surrounding landscape. . . (2001, 24).

Furthermore, Hogan and Fouberg have described the Pierre Hills as follows:

> They comprise a mature geologic subregion of smooth, rounded, contoured hills. The area is a result of erosion of dark Pierre shale bedrock, which breaks down into sticky clay called "gumbo." When

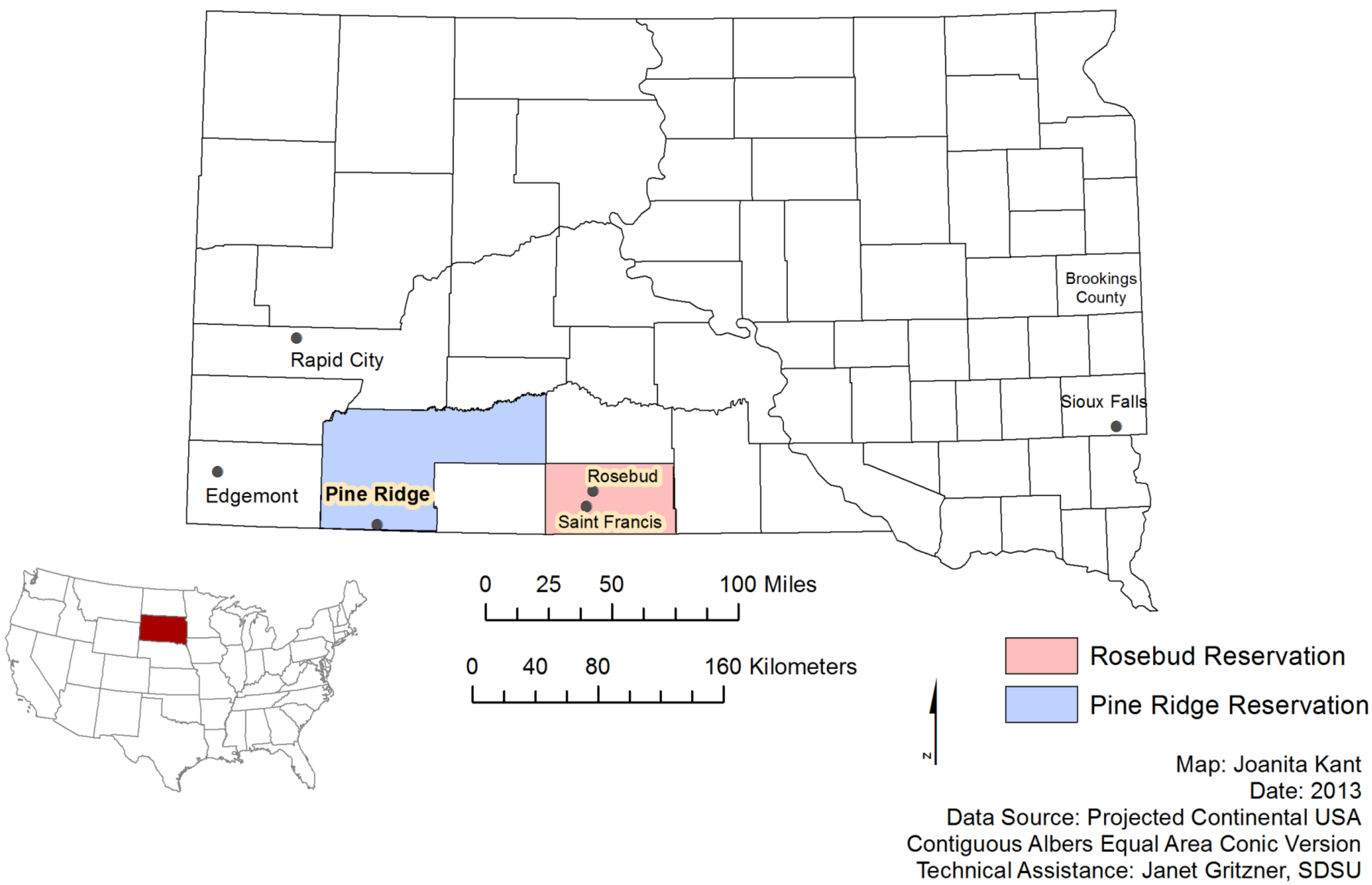


Figure 9. Rosebud and Pine Ridge Reservations borders, after South Dakota Official Highway Map, 2011. South Dakota Department of Transportation (State of SD copyright, with permission).

> wet, the clay resists water absorption and when dry, it tends to cake, flake, and decompose. . . .
>
> During wet periods, water that is unable to saturate the "gumbo" rapidly runs off the land, cutting deep into the land. In other places, valley water holes and intermittent standing pools collect the runoff. It then evaporates or very slowly seeps into the land.
>
> . . . Alkali spots contain a salt in the soil, resulting in a surface that is essentially devoid of vegetation (2001, 23).

As noted by Hogan and Fouberg, Westin (1977) divided the soil types in South Dakota into three types: Chernozem, Chestnut, and Gray Wooded, names used infrequently in the modern day. Chestnut soil type included the PRR and the remainder of the area west of the Missouri River, with the exception of the Black Hills. Chestnut soils formed in short grass steppes and exhibit shallow upper horizons from two to four inches (5.08 to 10.16 cm). These areas are generally marginal for crop production but can be fertile with adequate rainfall, requiring conservation techniques to reduce erosion risk (Hogan and Fouberg, 2001). While there are other modern soil classification systems, Brady and Weil (2008) introduced a common one used by Malo (2012) at South Dakota State University. Brady and Weil divided South Dakota soils orders into the following: Mollisols, Alfisols, Entisols, Vertisols, and Ardisols. Of those, PRR included Mollisols in the north and Entisols in the south. After Brady and Weil, Malo described Mollisols as, "Prairie derived, high humus . . . A horizon, deep dark colored surface, high fertility" with a formative element of Haplustoll. In addition, Malo described Entisols as, "Soils with no well developed [*sic*] pedogenic horizons" with formative elements of Udifluvent (Malo, 2012, 195-196; after Brady and Weil, 2008). Concerning major vegetation types, PRR, mostly included northern wheatgrass-needlegrass plains (Johnson and Larson, 2007).

The two major watersheds for PRR are the White River and the Cheyenne River, both of which flow east to northeast. Those rivers eventually converge with the Missouri River which flows south to the Gulf of Mexico.

The climate in South Dakota, west of the 100th Meridian (roughly west of the Missouri River) is dry continental. It is an area of low humidity with hot summers and the potential for bitterly cold winters. Summer temperatures occasionally exceed 100 degrees F (37.8 C) and winter temperatures often dip to below zero F (-17.8 C), with record-breaking extremes in the 1930s reported at 120 degrees F (48.9 degrees C) and -38 degrees F (-38.9 C) (South Dakota State Climatologist, 2013a).

The Porcupine, SD weather station on PRR reported temperatures from 1971 to 2000. Results indicated that temperatures for the months of January and February averaged 20 degrees F (-6.67 C) and 25.6 degrees F (-3.36 C), and for the months of July and August averaged 72.9 degrees F (22.72 C) and 71.4 F (21.89 C) during the same period, respectively (South Dakota State Climatologist, 2013b). Precipitation can be quite variable.

The average annual precipitation for South Dakota ranges from about 16 inches (40.64 cm) west of the Missouri River to about 26 inches (66.04 cm) in the southeastern corner of the state, reported by the South Dakota State Climatologist, in the *South Dakota Agriculture 2011* (USDA/NASS, 2012) report. The Porcupine, SD, station report noted that for 2010, the growing season precipitation for PRR (from April through September) was less than 15 inches (38.1 cm) with the exception of a small area in the northwestern corner; whereas, it ranged to above 30 inches (76.20 cm) for the southeastern part of the state. Growing season precipitation averages from 1971 through 2000, PRR (Shannon and the southern half of Jackson Counties) were from 12 to 16 inches (30.48 to 40.64 cm) (USDA/NASS, 2011).

South Dakota Agriculture 2011 listed Shannon County as having a 2010 Census population of 13,586. In addition, the report listed a land area of 1,340,131 acres (3,311,598 ha) with 1,333,708 acres (3,295,726 ha) in farms, including only 104,917 acres (259,260 ha) in cropland, ranked it 62nd of 66 counties in the state for the latter. Farm crops consisted mostly of non-alfalfa hay, alfalfa hay, corn, and oats. Cattle numbered 37,500 in the county as of January 1, 2011. In 2007, bison numbered 1,000, and horses, 2,509 (USDA/NASS, 2012).

As noted, PRR includes only the southern half of Jackson County. *South Dakota Agriculture 2011* listed data by county, not by reservation. Jackson County included a 2010 Census population of 3,031, and a land area of 1,196,347 acres (29,644,173 ha) with 1,184,156 acres (2,926,168 ha) of land in farms that included only 228,994 acres (565,867 ha) of cropland, ranking it 45th of 66 counties in the state for the latter. Farm crops most often reported included alfalfa hay, non-alfalfa hay, and oil sunflowers. Cattle numbered 51,000 as of January 1, 2011. In addition, horses numbered 2,080, placing both Shannon and Jackson Counties in the top eight of 66 counties in that category (USDA/NASS, 2012).

PREVIOUS HEAVY METALS RESEARCH IN AND NEAR THE STUDYAREA

Some other studies of heavy metals in South Dakota in recent years included two M. S. theses at SDSU by Faris (2012) and by Decoteau (2013). Faris studied heavy metal concentrations from snowfall and precipitation runoff for six bridges in Brookings County, South Dakota. Arsenic, lead, selenium, and other heavy metals concentration levels were reported in excess of US EPA Primary Drinking Water Standards. In Faris' study, a possible primary source of contamination could have been ash added to the deicing treatment obtained from a coal-fired electrical production plant in northeastern South Dakota (Faris 2012).

In Decoteau's heavy metals study, he reported collecting and analyzing river water and sediment samples in 2011 in northwest Nebraska and southwest South Dakota. He examined the White and Cheyenne River watersheds, south and west of PRR, as well as four sites along the White River within reservation boundaries. Results showed concentration levels of several heavy metals, including arsenic, barium, lead, selenium, and uranium, in excess of US EPA Primary Drinking Water Standards. The study concluded that the sources are probably naturally occurring and not necessarily the result of point source pollution caused by mining operations near the reservation (Decoteau 2013).

DeBoer, et al. (2005, 29) reported no significant difference in selenium levels between high selenium soils in Charles Mix County, South Dakota, when soils described as "derived from glacial till and collapsed drift geologic materials" were compared with unglaciated soils. Selenium levels increased with depth for both total concentration and highly available [inorganic] concentration. They reported average concentrations of total selenium at 0.929 ppm from the surface to 1.6 feet (0.49 m), and at 1.684 ppm at 6.6 to 9.9 feet (2.01 to 3.02 m). The average for highly available [inorganic] selenium ranged from 0.072 ppm at the surface to 0.662 ppm at greater depths. For comparison purposes, it is important to note that PRR is not in a glaciated area of the state. The current study results indicated much higher overall average concentrations of selenium in soils at 6.09 ppm.

Williamson et al. (1996) reported levels of heavy metals in sediment, plants, and fish in Rapid Creek at Rapid City, South Dakota during 1993-1994. While primarily interested in silver (Ag), cadmium (Cd), copper (Cu), and zinc (Zn), they found that levels in Rapid Creek water and plants were generally higher downstream from the local wastewater treatment plant. Levels did not consistently follow that pattern concerning fish livers, however. Their primary findings showed that water, bed sediments, plants, and fish bioaccumulated heavy metals, but there was no evidence of biomagnification:

> Based on the limited sampling during this study, there is evidence that the selected metals present in both the water and bed sediments are bioaccumulating in the plant and fish species. Results also indicate that biomagnification in the plants and fish is not occurring; that is, the concentrations found in the sediment, plants, and fish are all at about the same order of magnitude (1996, 1).

Williamson et al. (1996, 26-27) reported that bed sediments for arsenic (As) along Rapid Creek ranged from 10 to 20 micrograms per gram [ppm], lead (Pb) from 36 to 49, and uranium (U) <100.

Including soil samples from PRR, Gustavsson et al. (2001) reported baseline estimations for a variety of element concentrations in soils. The study is the most comprehensive for the conterminous United States based on samples taken by United

States Geological Survey teams in the 1960s and 1970s. The baselines developed by Gustavsson et al., based on reworked research by Shacklette and others (Shacklette et al., 1971; Boerngen and Shacklette, 1981; and Shacklette and Boerngen 1984) are among those used for comparisons in the current study.

HEAVY METALS OF INTEREST

As noted, heavy metals of interest included arsenic (As), barium (Ba), lead (Pb), selenium (Se), and uranium (U). While they are referred to as "heavy metals," technically speaking, they are elements on the periodic table, more properly described as follows: As is a metalloid; Ba is an alkali earth metal; Pb is a metal, Se is a nonmetal; and U is an actinide (with an atomic number of 92, within a group of radioactive metallic elements with atomic numbers ranging from 89 to 103). Heavy metals and other inorganic compounds are widespread and naturally occur in the environment. Although capable of building to toxic levels, some, such as selenium, are necessary micronutrients for good health.

Capable of high mobility in the environment, inorganics adsorb particularly to organic matter, mud, and clay. Inorganics are particularly soluble depending upon conditions in which they occur. Variability in hardness, pH, moisture, accompanying compounds, and other factors affect their solubility (US EPA, 2013e). Burckhard (1997) reported that organic acids in the presence of heavy metals influence adsorption rates in vegetation, with oxalic acid related to increases and citric acid related to decreases.

Of the heavy metals of interest, Cai (2003) noted that the US EPA considers two of them, arsenic and selenium, to be among the three heavy metals of particular interest to the US EPA in studying the chemistry of all things, both living and non-living. The other of the three is mercury. All three can be very toxic, causing harmful effects.

All the heavy metals of interest can cause adverse health effects when ingested as contaminants in drinking water. Living in areas with high naturally-occurring levels of heavy metals in soils may also be harmful to health.

ARSENIC

Arsenic, As, with an atomic number of 33, is a metalloid that mostly occurs in its natural state with other minerals and metals. Less often, As occurs as an element in pure crystalline form.

Anthropogenic activities can add to natural levels of As in the environment. As is particularly associated with wood preservative in industrial settings, pesticides, metallurgy, and mining residues. On a worldwide level, arsenic is a major problem in drinking water, particularly well water; also in rice, sea fish, apple juice, and some other fruit juices (US CDC 2013d and 2007a; and US EPA 2013e). Worldwide, regulatory agencies are currently reassessing and/or revising standards for safer levels that are economically feasible. Gebel (2000) found that arsenic, as a contributing factor in cancers, may vary between genetic sub-groups such as Mexican or Taiwanese populations. Therefore, he reported, that “Unfortunately, a toxicologically safe risk assessment and standard setting, especially for long-term and low-dose exposures to arsenic, is not possible” (Gebel, 2000).

BARIUM

Barium, Ba, with an atomic number 56, is a metallic alkaline earth metal. In nature, Ba is not found in a free state, but rather as one of its compounds, many of which are potentially toxic.

Anthropogenic activities can add to natural levels of Ba compounds in the environment. The workplace can be an important source of exposure. Others sources include drill bit lubricants that include barium compounds in the gas and oil industry, pigment in paints, medical x-rays, fireworks, rubber, fluorescent bulbs, pesticides, ceramics, plastics, and glass (US CDC, 2013d and 2007b; and US EPA 2013e).

LEAD

Lead, Pb, is classified as a metal, with an atomic number 82. It mostly occurs in nature in ores, especially copper, silver, and zinc.

Anthropogenic activities can add to natural levels in the environment. It is particularly problematic in water and sewer pipes, solders and lead-based paints, and in old construction projects. It is commonly used in automobile batteries, radiation shields, dishware and ceramic glazes, weights, and ammunition. In recent years, lead shot has been replaced by steel shot for waterfowl hunting in an effort to reduce contamination levels. Pb release into the environment is associated with metallurgy and mining. Worldwide, regulatory agencies are reassessing and/or revising standards for safer levels that are economically feasible. Pb may pose health risks at very low levels, particularly for children. Pb is considered a worldwide concern in drinking water for humans (US CDC, 2013d and 2007c; and US EPA 2013e).

SELENIUM

Selenium, Se, is classified as a nonmetal, atomic number 34. Se most often occurs in nature in metal sulfide ores, particularly in copper mining, rather than in a pure state as an element or a compound. Se naturally occurs in fossil fuels, as well as igneous and sedimentary rock (Ohlendorf, 1989).

Anthropogenic activities such as mining can add to natural levels in the environment. Particular contaminant sources include agricultural and industrial runoff and ash from coal burning (Ohlendorf, 1989). In addition, Se is often used in electronics, rubber, glassmaking, pigments, metallurgy, fungicides, and medical imaging procedures. Food supplements containing Se are commonly sold, since trace amounts are essential in human and animal diets (US CDC, 2013d and 2013c; and US EPA, 2013e).

Veterinaries, ranchers, and farmers recognize Se as potentially problematical for livestock which graze plants or eat hay contaminated with high Se from soil uptake. Se can be toxic for humans and livestock at unusually variable concentrations, resulting in symptoms of selenosis. Other researchers, including Ohlendorf (1989), report that selenium is capable of bioaccumulation and biomagnification.

Certain plants require or tolerate large amounts of selenium. Johnson and Larson (2007) reported that some plants are indicators of Se soils, including plants commonly found in pastures in western South Dakota. Those involve some species in the

Brassicaceae, such as prince's plume (*Stanleya pinnata*), and some Fabaceae, e.g. species of *Astragalus,* the poison vetches.

Human studies have shown that up to 0.853 mg/day is sometimes tolerated by certain individuals but not by a subset of particularly sensitive individuals (Yang, et al, 1989 and Longnecker et al., 1991).

URANIUM

Uranium, chemical symbol U, is an element classified as an actinide. Its atomic number is 92 within a group of radioactive metallic elements with atomic numbers ranging from 89 to 103. In nature, U often occurs in mineral form, such as uraninite. Found in low concentrations in water, soil, and rock, U is highly inorganic with no organic form in nature (Emsly, 2001).

Anthropogenic activities add to natural levels of U exposed in the environment. Of most importance is uranium mining. Uranium's most important uses are as fuel for power-generating nuclear reactors and for nuclear weapons. The inorganic form normally used in nuclear reactors, is isotope U235, although U238 is used in fast reactors.

LITERATURE REVIEW

OVERVIEW OF SPECTROMETRY TESTING IN FOODS

Among researchers worldwide, it is common practice to detect trace element concentrations using spectrometry methods, particularly inductively coupled plasma optical emission spectrometry (ICP-OES), atomic absorption spectroscopy (AAS), and inductively coupled plasma mass spectroscopy (ICP-MS). Each technique has unique advantages and disadvantages. ICP-OES was appropriate for the current study, with a goal of establishing a preliminary baseline of heavy metals, because it is effective in terms of time and cost and capable of detecting a wide variety of elements in a single sample. AAS requires five separate runs for every sample and only detects one element at a time. MS is capable of detecting specific isotopes, although at a higher cost, if there is some reason to look more closely in follow-on studies. Spectrometry has been used for decades to detect heavy metals concentrations in environmental samples including foods, plants, aqueous solutions, sludge, soil, sediment, and oil. Its use has surged since the 1980s, although the basic principles were understood much earlier.

The current research samples were processed using ICP-OES. The method involves an atomic emission occurring when certain atoms are passed into a flame. Metals are differentiated from one another based on the wavelengths of the atomic emission. Since ground state metals are known to absorb light at particular wavelengths, when light is supplied to the sample, the absorbed light is compared to a standard curve to identify the quantified "signature" of the isotopes or element concentrations. Atomic absorption spectrometry is based on Gustav Kirschoff's law, "Matter absorbs light at the same wavelength at which it emits light," discovered in the 1800s (Haswell, 1991).

Table 8 presents a sampling of spectrometry research studies in foods, including results and the country of origin. A search of the literature showed that spectrometry testing is worldwide, with research interests in a broad range of elements and food types in both human and animal studies. While only five heavy metals, arsenic, barium, lead, selenium, and uranium, are of concern in the current study, many other research studies do not include all of them. Food studies including arsenic and lead were common. Such studies have proliferated since the 1970s resulting in a vast amount of data. In response, various worldwide agencies increasingly establish baselines, summaries, assessments and evaluations drawing conclusions for guidance and regulations. Those are presented later in this chapter.

Table 8. Spectrometry research studies in foods: Detecting heavy metals and other elements.

Elements	Tested	Result	Country	Reference
Ca, Mg, Na, K	meat, fish, dairy, & vegetables	Focus was using simultaneous techniques with an individual sample using spectrometry to analyze nutrients and elements in food	France	Chekri et al., 2010
Cu, Cd, Zn	watermelons	Levels excessive and a threat when plants are irrigated with urban wastewater, although water-melons fruits have a natural filtering mechanism; warned that spectrometry in general is prone to errors	Iran	Khanjani et al., 2008
Al, Cd, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Ti V, Zn	berries and mushrooms	These elements are not subject to bio-accumulation from heavy metals contamination in wood ash	Finland	Moilanen et al., 2006

Table 8. Spectrometry research studies in foods: Detecting heavy metals and other elements (continued).

Elements	Tested	Result	Country	Reference
As, Cu, Mi, Mn, Zn, Se	water, vegetables, cereals, and bakery items	As, in particular, was high in local water sources; thereby, it contaminated local foodstuffs	India	Roychowdhury, et al., 2003
Ag, Cd, Cu, Zn	plants and fish	Bioaccumulation of certain metals likely, based on small sampling in Rapid Creek	United States (South Dakota)	Williamson, et al., 1996
Pb, Cd, Cu, Zn	various market fruits and vegetables, including strawberries, cucumbers, dates, and spinach	In comparing these with others around the world, they were within WHO/ FAO accepted standards for daily intake estimates	Egypt	Radwan and Salama, 2006
Cd, Cu, Pb, Zn	various green vegetables	Some plants grown along rivers exceeded WHO/FAO standards	Tanzania	Bahmuka and Mubofu, 1999

Table 8. Spectrometry research studies in foods: Detecting heavy metals and other elements (continued).

Elements	Tested	Result	Country	Reference
Cr, Co, Cu, Ni, Pb, Zn	various vegetables, spinach, onion,	All showed detectable levels, but all were within standards set by the National Agency for Food and Drug Administration Control (NAFDAC)	Nigeria	Lawal and Audu, 2011
Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn	various market fruits: oranges, bananas, pomegranates, lemons, pears, Chiku fruits, apples, mangoes, guavas, grapes, mandarins	All exceeded legal safety levels of the Indian Food Adulteration Act of 1954, less stringent than other European Union Standards	India	Mahdavian and Somashekar 2008
Cu, Zn, Pb, Cr, Cd, Mn	green leafy vegetables: palak and coriander	Many exceeded WHO standards, Pb particularly high	India	Ramesh et al., 2012
As, Cd, Pb, Zn, Cu	commercial and residential vegetable gardens: lettuce, spinach cabbage, leek rhubarb, beetroot parsley, mint	Some exceeded Australian, New Zealand, European, and Codex Alimentarius Commission standards, particularly near smelters	Australia	Kachenko, et al., 2006

HEALTH EFFECTS OF HEAVY METALS TOXICITY

Health concerns from exposure to toxic concentrations of heavy metals, through ingestion, inhalation, and dermal contact, are widely acknowledged in scientific literature. Research on the topic is rapidly expanding, as noted. Overviews of health effects for each heavy metal of interest follow. A selection of recent worldwide trace metal toxicity studies and health effects for the heavy metals of interest are presented in Table 9.

Inorganic arsenic is particularly toxic, occasionally fatal, with the potential to accumulate in cells of the body and increasing the chances of cancers including those of the bladder, liver, lung, and skin. In addition, inorganic arsenic may adversely affect the following systems or organs in humans: cardiovascular, blood and bone, gastrointestinal, kidney, pancreatic, brain, and others (US CDC, 2013d and 2007a; Vigo and Ellzey, 2006; and Oluwole, 2011). Very little is known about the effects on human health for organic arsenic (US EPA 2013e).

Barium toxicity is directly related to its ability to dissolve in water and in human intestines. Barium toxicity particularly affects the human gastrointestinal and muscular systems. Long-term exposure to soluble barium may cause disturbances in the lungs and cardiovascular system (US CDC 2013d and 2007b; and US EPA 2013e). Barium potentially accumulates in fish and aquatic organisms (Eisler, 1988). The US EPA reported that barium is unlikely to be a human carcinogen (US EPA, 2013e).

Lead toxicity affects nearly every organ system of the human body. In particular, lead adversely affects the human nervous system. High exposure levels target the brain, kidneys, blood, and reproductive system. Lead is a probable human carcinogen (US CDC, 2013d and 2007c; US EPA, 2013e; Knobeloch et al., 2006; and Leonardi et al., 2012). Eisler (1988) reported adverse effects in plants; however, inorganic lead contamination in food has mostly been associated with lead-based paint, lead shot, and lead weights.

Selenium enters the food chain through sediments and in water. The US EPA (2013e) lists the following health concerns for selenium toxicity: "loss of equilibrium and other neurological disorders, liver damage, reproductive failure, reduced growth, reduced movement rate, chromosomal aberrations, reduced hemoglobin and increased white blood cell count, and necrosis of the ovaries." The US CDC specifically includes symptoms of selenosis: hair loss, fingernail and toenail irregularities, and tingling sensations in the extremities. In addition, the CDC reports that selenium intake may actually decrease cancer risk (US CDC 2013d and 2013c).

Uranium toxicity targets human kidneys in both the natural or depleted forms of the element. As with other heavy metals, soluble forms of uranium produce damage at lower concentrations than insoluble forms. According to the US CDC, although natural uranium is mildly radioactive, adverse health effects are caused by the chemical exposure, not the radiation. Human food exposure is often through root vegetables and the soils in which they grow. Concerning cancer causing potential, the US EPA has not classified uranium (US EPA 2013e and US CDC 2013d and 2007d).

Uranium toxicity health effects were also compiled by Craft, et al. (2004). Adverse effects were noted in animal and human studies. Human body systems negatively affected include renal, brain and central nervous system, DNA (associated cancers), reproductive, gastrointestinal, immune system, and cardiovascular. Table 9 presents a survey of studies estimating potential health risks from heavy metals toxicity.

Table 9. Potential health effects of heavy metals toxicity

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Arsenic	persistent arsenicosis	groundwater aquifers as drinking water and	Bangladesh	Mukherjee and Bhattacharya, 2001
Arsenic	skin lesions	drinking water	Chile	Smith et al., 2000
Arsenic	liver disease non-cirrhotic fibrosis	drinking water	India	Santra et al., 2000
	skin lesions	water	Bangladesh	Hall et al., 2006
Arsenic	cardiovascular degeneration	water	Taiwan, Bangladesh, India, Argentina, Australia, Chile, Australia, Chile, China, Hungary, Peru, Thailand, Mexico, USA	Balakumar and Kaur, 2009
Arsenic	Ischemic heart disease	artesian drinking water	Taiwan	Tseng et al., 2003
Arsenic	may increase risk of Type 2 Diabetes	drinking water	USA	Navas-Acien et al., 2008
Barium	reduced life-span, reproduction, development (size), and motor skills in soil nematodes	deliberate exposure to barium in laboratory	China	Wang and Wang, 2007

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Barium	reduced weight ratios in liver, brain, kidney, ovary (and survivability in females in amounts over 300 mg/kg, 1 to 10 day gavage; no changes at levels below 209 mg/kg. in lab rats	deliberate exposure BaCl2 in laboratory	USA	Borzelleca et al., 1988
Barium	hypertension if in 95th Percentile of "established reference dose"	ceramic glaze in dishes	USA	Assimon et al., 1997
Barium (reactive salts)	multiple sclerosis, transmissible spongiform encephalopathies, amyotrophic lateral sclerosis	workplaces/environment various	Colorado, Guam, Massachusetts, Sardinia, Scotland, Saskatchewan	Purdey, 2004
Barium Sulfide	"produces characteristic gastrointestinal symptoms, periorbital and extremity paresthesia, hypertension, and progressive flaccid muscular paralysis. Profound hypokalemia also may be induced. Overdose may be rapidly fatal unless the ingestion is recognized and appropriate treatment. . . immediately."	shaving cream ingestion, suicide	USA	Downs and Nichols, 1995

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Lead	impaired neurological development; harm to nearly all organ systems, genotoxic, particularly in children	naturally occurring in environment; anthropogenic introduction in various products: car battery, paint, solder, ceramics, ammunition; industrial waste	USA Israel	Sanders, et al., 2009
Lead	death of condors	ingesting lead shot from hunting gut piles	USA	Green et al., 2008
Lead	kidney toxicity	various environmental and anthropogenic sources with increased incidence when co-occurring with poverty, obesity, and diabetes	USA	Ekong et al., 2006
Lead	Burton's Line, blue line along gums; children: "irritability, loss of appetite, weight loss, sluggishness, behaviour (continued)	various environmental and anthropogenic sources	UK	Pearce, 2007

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
	abdominal pain, vomiting, constipation, anaemia and renal failure.” Adults: pain, numbness or tingling of the extremities, muscular weak-ness, headache, abdominal pain, memory loss, anaemia and renal failure, male reproductive impairment.”			
Lead	reduced brain size in adults with history of childhood lead exposure, resulting in cognitive impairment	various environmental	USA	Cecil, et al., 2008
Selenium	possible increase diabetes in adults	not specified	USA	Bleys et al., 2007
Selenium	slowed growth; enlarged livers; and mortality for 97.5%-100% of mallard ducklings at maximum dose	10 to 80 ppm/d in controlled setting	USA	Heinz et al., 1988

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Selenium	deficiency of is associated with Ketogenic diet in epileptic children	Ketogenic diet for epileptic children	USA	Bergqvist et al., 2003
Selenium	reproductive failure; deformities; mortality, irregularities in blood, eyes, liver, heart, kidney in fish	coal wastewater	USA	Lemly, 2002
Selenium	diarrhea, fatigue, hair loss, finger-nail disfiguration joint pain, nausea	dietary supplement at over 750 x recommended daily allowance	USA (10 states)	MacFarquhar et al., 2010
Uranium	depending upon the species, soluble uranium is of most interest and increases kidney disease, and increases risk of various forms of cancer	eating and/or breathing from industrial sources or environment	USA	Argonne National Laboratory, 2012
Uranium	lung cancer among Navajo 1969-1993	working in uranium mine	USA	Gilliland et al., 2010

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Uranium	slight increase of leukemia for men and kidney and lung cancers for women	drinking water, mostly below 20 µg/L [0.020 ppm]	Germany	Radespiel-Tröger and Meyer, 2012
Uranium	potentially toxic as an element, causing “non-malignant respiratory disease (fibrosis, emphysema) and [probably ‘reversible’] nephrotoxicity”; but no studies show that uranium causes cancers because of its radioactivity, as is commonly believed.	working in mines, mills, and uranium facilities	USA	Gehle, 2012 for US Health and Human Services continuing medical education website
Uranium	“Intakes of uranium exceeding EPA standards can lead to increased cancer risk, liver damage, or both. Long term chronic intakes of uranium isotopes . . . can lead to internal irradiation and/or chemical toxicity. . . .”	“food, water, or air”	USA	United States Environmental Protection Agency, 2013b

STANDARDS AND RISK ASSESSMENTS FOR HEAVY METALS

US EPA NATIONAL PRIMARY DRINKING WATER REGULATIONS FOR SELECTED HEAVY METALS

United States Environmental Protection Agency (US EPA, 2013a) establishes National Primary Drinking Water Regulations (NPDWR or primary standards) for contaminants including heavy metals of interest in this study. The primary standards are based on inorganic forms of arsenic, barium, lead, and selenium, rather than totals of organic and inorganic. The NPDWR sets unenforceable Maximum Contaminant Level Goals (MCGLs) below which negative health effects are not expected. In addition, they establish MCLs (Maximum Contaminant Levels) that are both enforceable and achievable in terms of technology and price (2013a).

The NPDWR are widely referenced because they are easily accessible and simple to understand. US EPA National Primary Drinking Water Regulations for the heavy metals of interest are presented in Table 10. They include MCLs and MCLGs, as well as summaries of adverse health risks. They are useful for reference, but it is important to remember that drinking water is ingested on a daily basis, and in many countries it is used for bathing; whereas, exposure to a particular food may be much less frequent. Thus, foods require their own standards, and they may or may not exist for many of the heavy metals in question. Also, existing standards may not apply to particular foods of interest.

Table 10. US EPA National Primary Drinking Water Regulations: MCGLs and MCLs, potential health effects, and sources of contaminant (directly quoted and extracted from US EPA, 2013a)

Contam-inant	MCLG [mg/L]	MCL or TT[1] (mg/L)[2] [except U]	Potential Health Effects from Long-Term Exposure Above the MCL	Sources of Contaminant in Drinking Water
As_i	0	0.010 as of 01/23/06	Skin damage or problems with circulatory systems, and may have increased risk of cancer	Erosion of natural deposits; runoff from orchards, runoff from glass and electronics production wastes
Ba_i	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Pb_i	0	TT[7]; Action Level =0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities	Corrosion of household plumbing systems; erosion of natural deposits
Se_i	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
U	0	30 ug/L as of 12/08/03 [=0.03 ppm]	Increased risk of cancer, kidney toxicity	Erosion of natural deposits”

[Selected]Notes:

“[1] . . . Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs [Maximum Contaminant Level Goals] as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards. . . .

[2] Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

[7] Lead and copper are regulated by a Treatment Technique [TT] that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.” Superscripts 3-6 were omitted because they are not applicable to the elements of interest. Subscript “i” indicates “inorganic.”

SELECTED STANDARDS, RISKS ASSESSMENTS, AND GUIDANCE FOR FOOD AND SOIL

CAUTIONS IN USING STANDARDS AND RISK ASSESSMENTS

Duffus (2002) noted that "heavy metals" do not necessarily equal toxicity. He explained that,

> "Understanding bioavailability is the key to assessment of the potential toxicity of metallic elements and their compounds. Bioavailability depends on biological parameters and on the physic-chemical properties of metallic elements, their ions, and their compounds. These in turn depend upon the atomic structure of the metallic elements, which is systematically described by the periodic table. Thus, any classification of the metallic elements to be used in scientifically based legislation must itself be based on the periodic table or some subdivision of it.
> . . . If metallic elements are to be classified sensibly in relation to toxicity, the classification must relate logically to the model adopted for carbon and each metal species and compound should be treated separately in accordance with their individual chemical, biological, and toxicological properties (2002, 804).

Many studies of heavy metals do not differentiate between their inorganic and organic forms (Yong Cai, 2003). Instead, researchers often report combined totals. Since the inorganic form is most readily absorbed in humans and animals, it is of most concern. By reporting total concentrations of heavy metals, researchers may overstate the risks. Until such time when researchers routinely differentiate between inorganic and organic, allowable concentrations of heavy metals established by standard-setting agencies are not as useful as they could be because of lack of equivalency in comparisons.

When drawing risk conclusions based on established concentration standards for heavy metals, it is important to take into consideration the toxic potential of the element, the amount of exposure, the body weight of the human or animal, age, condition of health and overall nutrition, possible genetic predisposition related to sensitivity or lack thereof, possible tolerance buildup through gradual exposure, and the presence or absence of other elements, as well as many other factors. Maines noted, in published chart form, individual differences in exposure to toxic metals may include “protein binding, sex, genes, pregnancy, occupation, drugs, season, diet, exercise, duration, chemicals, stress, disease state, gastrointestinal function, renal function, temperature, [and] age” (1994, 22). In addition, Maines reported that individual organs may respond to heavy metals in various ways based on “metal binding proteins, organ region, blood perfusion, drugs/chemicals, steroids, transport protein receptors, metal/metal interaction, organelle, cell type, GSH[glutathione]/cysteine, [and] oxidative stress” (1994, 23).

FOOD STANDARDS FOR HEAVY METALS

It is of interest to note that the media plays a role in calling attention to heavy metals that can lead to advocacy for standards. Of particular recent interest in the news are levels of As in rice, and levels of As and Pb in fruit juice. The US FDA came under increasing pressure in 2012 from Representatives Frank Pallone (Democrat, New Jersey) and Rosa DeLauro (Democrat, Connecticut) to consider establishing standards for As and Pb in certain fruit juices. Lawmakers are pressing for US FDA standards for heavy metals, including As and Pb, for all food products under their jurisdiction (Bottemiller, 2012).

While many countries have their own standards for contaminants in food, the following sections discuss selected standards for the United States, Australia and New Zealand, the World Health Organization (WHO), and the Government of Hong Kong.

US EPA'S REFERENCE DOSES (RFDS) INCLUDE FOOD

The current study reports concentrations of combined totals of organic and inorganic forms of arsenic, barium, lead, and selenium; and total uranium. Typically, the published standards and much of the guidance for comparison are for inorganic forms or specific isotopes only. The United States Environmental Protection Agency's Integrated Risk Information System (US EPA's IRIS) (2013c) chronic, oral, daily reference dose (RfD) levels were searched for the heavy metals of interest. An IRIS RfD is a usually non-carcinogenic "estimate … of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime" often determined from lowest-observed-effect levels (LOAELs) and no-observed-effect levels (NOAELs) or, since 1995, benchmark dose (BMD) and lower-bound confidence limit (BMDL) (US EPA, 2013d). When an RfD includes a carcinogenic estimate, it is included as Part II of the IRIS explanatory data (US EPA, 2013c), as discussed elsewhere in this research.

The search for standards and guidance included arsenic, barium, lead, selenium, and uranium. RfDs established by the US EPA are presented in Tables 11-14. The RfDs are specifically for inorganic arsenic, for barium and compounds, and for selenium and compounds. While the US EPA set an RfD for "uranium soluble salts," based on uranyl nitrate hexadyrate in food converted to urnium for the lowest-observed-adverse-effect level (LOAEL) needed to extrapolate an RfD, they established none for "natural uranium."

Table 11. Food: Chronic oral reference dose (RfD) for inorganic arsenic established by US EPA (after US EPA, 2013c).

Element	Critical effect	Dose NOAEL mg/kg/bw/day	Dose LOAEL mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Data last revised
Inorganic arsenic	Hyperpigmentation, keratosis and possible vascular complications Human chronic oral exposure (Tseng, 1977; Tseng et al., 1968)	0.0008	0.014	0.0003	55 kg	2/1/1993

Table 12. Food: Chronic oral reference dose (RfD) for barium established by US EPA (after US EPA, 2013c).

Element	Critical effect	Dose BMDL Statistical lower confidence limit on benchmark dose BMD, 5% extra risk mg/kg/bw/day	Dose BMD Maximum likelihood estimate of dose, 5% extra risk mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Date last revised
Barium and compounds	Nephropathy 2-year drinking water study in mice (NTP, 1994)	63	84	0.20	55 kg	7/5/2005

Table 13. Food: Chronic oral reference dose (RfD) for selenium and compounds established by US EPA (after US EPA, 2013c).

Element	Critical effect	Dose NOAEL mg/kg/bw/day	Dose LOAEL mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Data last revised
Selenium and compounds	Human epidem-iological study, clinical signs of selenosis in 5/349 adults in high selenium soils area (Yang et al., 1989)	0.015	0.023	0.005	55 kg	9/1/1991

Table 14. Food: Chronic oral reference dose (RfD) for uranium soluble salts (after US EPA, 2013c).

Element	Critical effect	Dose NOAEL mg/kg/bw/day	Dose LOAEL mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Data last revised
Uranium soluble salts as uranyl hexadyrate	Initial body weight loss; moderate nephrotoxidity 30-day oral rabbit bioassay (diet) (Maynard and Hodge, 1949)	none	2.80	0.003	55 kg	32782

US EPA IRIS CANCER RISK ASSESSMENTS

In addition to the non-cancerous RfDs above, the US EPA Integrated Risk Information System IRIS (US EPA, 2013c) assesses cancer risks associated with the heavy metals of interest. The weight of evidence for inorganic arsenic shows increased lung cancer, internal organ cancers, and skin cancer. Barium and its compounds were not assessed for cancer risk by the US EPA, and the weight of evidence shows that Ba is not classified as a human carcinogen. Inorganic lead and its compounds were assessed for cancer risk. They are probable human carcinogens, and the weight of evidence shows that in animals lead and associated compounds are related to renal tumors and are expressed through their influence on gene expression. Selenium and compounds were not classifiable as human carcinogens by the US EPA, but there were conflicting research results. However, in the weight of evidence narrative, selenium sulfide is a probable human carcinogen. Natural uranium was not assessed as a carcinogen by the US EPA, or the information was withdrawn (US EPA, 2012c).

US CENTERS FOR DISEASE CONTROL (US CDC) MINIMAL RISK LEVELS (MRLS) FOR ORAL AND INHALANT EXPOSURE ROUTES

The US Centers for Disease Control and Prevention (US CDC), Agency for Toxic Substances and Disease Registry (ATSDR) provides continuously updated risk assessments for potentially toxic substances. The US CDC publishes a Priority List of Hazardous Substances, identified in cooperation with the US EPA in compliance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and amended in the Superfund Amendments and Reauthorization Act (SARA) (US CDC/ATSDR, 2011). Of the 275 substances on the updated 2011 priority list, arsenic, barium, lead, selenium, and uranium ranked, respectively, as 1, 126, 2, 146, and 97. These are not necessarily the "most toxic" substances, but for National Priority List (Superfund) sites, their ranking is based on "frequency, toxicity, and potential for human exposure" (US CDC/ASTDR, 2011). In addition, ATSDR provides minimum risk levels (MRLs) based on NOAELs for potentially toxic substances, including oral routes of exposure listed in Table 15 (2013a and 2013b) (although none no MRL is established for lead). ASTDR defines MRLs and appropriate uses, as follows:

The ATSDR Minimal Risk Levels (MRLs) were developed as an initial response to the mandate [CERCLA and Superfund law]. Following discussions with scientists within the Department of Health and Human Services (HHS) and the EPA, ATSDR chose to adopt a practice similar to that of the EPA's Reference Dose (RfD) and Reference Concentration (RfC) for deriving substance specific health guidance levels for non-neoplastic endpoints. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. These substance specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites. **It is important to note that MRLs are not intended to define clean up or action levels for ATSDR or other Agencies (**emphasis theirs; US CDC/ATSDR, 2013b).

Table 15. Oral and inhalation minimal risk levels (MRLs) established by the US CDC. Inhalation exposure MRLs are expressed for particles (after US CDC/ATSDR, 2013b). Key: acute =1 to 14 days; intermediate = 15 to 364 days; chronic= > l year. None established by US CDC for lead.

Analyte	Route	Duration	MRL as daily human dose, non-carcinogenic	Endpoint	Date
Arsenic	oral	acute	0.005 mg/kg/day	gastrointestinal	Aug. 2007
	oral	chronic	0.0003 mg/kg/day	dermal	Aug. 2007
Barium	oral	intermediate	0.20 mg/kg/day	renal	Aug. 2007
soluble salts	oral	chronic	0.20 mg/kg/day	renal	Aug. 2007
Selenium	oral	chronic	0.005 mg/kg/day	dermal	Sept. 2003
Uranium	inhalation	intermediate	0.001 mg/m^3	renal	Feb. 2013
soluble salts	inhalation	chronic	0.00004 mg/m^3	renal	Feb. 2013
	oral	acute	0.002 mg/kg/day	developmental	Feb. 2013
	oral	intermediate	0.0002 mg/kg/day	renal	Feb. 2013
Uranium	inhalation	intermediate	0.002 mg/m^3	renal	Feb. 2013
insoluble compounds	inhalation	chronic	0.008 mg/m^3	respiratory	Feb. 2013

OTHER FOOD STANDARDS

Research was conducted to determine other world standards for all of the elements of interest applicable to food. Also, generally expected levels (GELS) from Food Standards Australia New Zealand (FSANZ) are included in the following sections. GELs are defined as “a range of contaminant levels that would normally be expected in particular foods” (FSANZ, 2001, 3).

ARSENIC: OTHER FOOD STANDARDS

FSANZ (2013) established maximum levels (MLs) of certain metals and their compounds in those foods deemed significant in the diets of persons in Australia and New Zealand. In many cases, FSANZ did not include fruits, or there was inconclusive or insufficient scientific evidence to include other food categories. FSANZ established “total arsenic” ML concentrations of 1.0 mg/kg for only one class of foods, cereals. Inorganic arsenic MLs were set for crustacean, fish, mollusks, and seaweed ranging from 1 to 2 mg/kg, since fish consumption is high and the inorganic form of arsenic is potentially more toxic (FSANZ, 2013).

In 2001, FSANZ (2001 and 2013) reviewed and revised all GELs for metal contaminants in light of increased research data. FSANZ proposed a GEL for “total arsenic” guidance, only for meat, but not for other any other food categories, with GEL medians ranging from 0.01 to 0.20 mg/kg and 90^{th} percentiles ranging from 0.02 to 1 mg/kg (2001).

The Government of Hong Kong (Choi, 2011) set a standard for inorganic arsenic at 1.4 mg/kg for solid food, 0.14 mg/kg for liquid food, 6.00 mg/kg for fish, and 10 mg/kg for shellfish.

WHO/FAO's Codex Alimentarius (as amended, 2012) assessed inorganic arsenic in food as presented by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). Inorganic arsenic (shown in the JECFA table as "arsenic," but footnoted as based on "inorganic arsenic") standards for oils, fats, and natural mineral water were set at 0.10 ppm, and salt at 0.50 mg/kg.

In addition, US FDA (2009a) set MCLs for inorganic arsenic in bottled water, equivalent to US EPA Primary Drinking Water Regulations at a concentration of 0.01 mg/L.

BARIUM: OTHER FOOD STANDARDS

Few food standards were found for barium. Bottled water is regulated as a food by the United States Food and Drug Administration (US FDA). The US FDA follows the US EPA's primary drinking water standard of an MCL of 2 mg/L and a maximum contaminant goal level (MCGL) of 2.9 mg/L for bottled water (US FDA, 2002 and US EPA, 2013).

LEAD: OTHER FOOD STANDARDS

Concerning lead, while US EPA set no RfD (2013c), the World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO), and FSANZ, set maximum levels (MLs) for fruits. The WHO/FAO Codex Alimentarius

(2012) set a lead concentration ML at 0.20 mg/kg for berries and small fruit, at 0.05 mg/kg for fruit juice, and at 0.10 mg/kg for pome and stone fruits, and 100 Bq/kg for infant foods. In addition, WHO/FAO (2000) approved a provisional tolerable weekly intake (PTWI) of lead as 0.025 mg of lead per kg of body weight per week (expressed as mg/kg/bw/week) approved by the 53rd meeting of the Joint FAO/WHO Expert Committee on Food Additives.

In 2001, FSANZ withdrew and revised former GELS, and none were approved for lead. FSANZ noted that GELS are not appropriate for lead because of the high potential for human toxicity at extremely low levels, particularly for infants and children. They advise that lead levels should be kept as low as possible and that there may be no safe level, particularly for vulnerable individuals (FSANZ, 2001). FSANZ (2013) set the lead ML for fruit at 0.10 mg/kg with other foods ranging from 0.10 to 2 mg/kg.

The US FDA MCL for lead in candy and candy wrappers is 0.10 mg/kg (US FDA, 2006). Concerning bottled water, US FDA MCLs are less stringent than US EPA domestic drinking water standards, since lead pipes are a not generally problematic in bottled water. Thus, US FDA set MCLs at 0.005 ppm for bottled water, when lead occurs consistently in test samples (US FDA, 2002 and Sharfstein, 2009), as compared to 0.015 ppm for National Primary Drinking Water Regulations of the US EPA (US FDA, 2013a). Otherwise, US FDA (2006) handles heavy metals toxicity issues in food on a case by case basis if a reason for concern has been identified.

SELENIUM: OTHER FOOD STANDARDS

FSANZ (2001) established a GEL for selenium for crustacea, mollusks, and edible offal and meat from cattle, swine, sheep, and fish with medians ranging from 0.50 to 1.0 mg/kg and 90th percentiles ranging from 0.2 to 2.0 mg/kg.   FSANZ (2013) set no MLs for selenium.

URANIUM: OTHER FOOD STANDARDS

Food standards for uranium, as set by the WHO/FAO Codex Ailmentarius (amended 2012), apply to catastrophic releases of radionuclides. However, FSANZ (2013) set no MLs for uranium.

SOILS: HEAVY METALS BASELINES FOR COMPARISON

Many countries set their own standards for heavy metals contamination in soil and sediment. Selected baselines or standards that follow include some from the United States and Brazil.

Gustavsson (et al., 2001) and others produced baselines with color-coded maps representing concentration levels for comparisons of elements in soils for the conterminous United States, including PRR. Their new baselines resulted from revised and extracted data from United States Geological Survey (USGS) research by Shacklette et al., 1971; Boerngen and Shacklette, 1984, and Shacklette and Boerngen, 1984. In the original research by Shacklette and others, a USGS team collected soil samples at sites about every 80 km across the conterminous United States from 1961 to 1975 (Fig. 10). Results included slightly over 1,300 samples that were analyzed for a variety of trace elements. The reworked results by Gustavsson et al. (2001) comprise the largest comprehensive database and color-coded maps of element concentrations for the conterminous United States available to date. The publication by Gustavsson et al. included arsenic, barium, lead, and selenium, although the original research by Shacklette and others also included uranium. Gustavsson et al. (2001) applied moving weighted-median and Bootstrap statistical processes that smoothed the 1960s and 1970s results of Shacklette and others, not including uranium. The statistical technique involves random resampling of the original database and replacing some of the values using computer programs. Such statistical manipulation is useful for massive databases where only a few samples represent a large area.

A comparison is presented in Table 16 of the statistically reworked data, as described above, reported by Gustavsson et al. (2001) based on original fieldwork reported by Shacklette and Boerngen (1984) and others. In the case of PRR, results are based on about four sites (Fig. 10) sampled and reported by Shacklette and Boerngen others from 1961 to 1975 (1984). Baseline distribution maps for the conterminious United States for arsenic, barium, lead, and selenium are reproduced in Figs. 11-14 after Gustavvson et al. (2001) with no map available for uranium.

Table 16. Soils: USGS baselines for comparison with natural or anthropogenically-influenced geochemical variations (modified after Gustavsson et al., 2001, who modified after Shacklette and others), USA conterminous, 1961-1975, 24 cm.

Element	Weighted-median and Bootstrap-based (Gustavsson et al., 2001) range, ppm	(Shacklette and Boerngen, 1984) range, ppm	(Shacklette and Boerngen, 1984) arithmetic mean, ppm
Arsenic	3.10-11	<0.10-97	7.20
Barium	241-945	10-5,000	580
Lead	10.30-30.10	<10-700	19
Selenium	0.17-0.74	<0.10-4.30	0.39
Uranium	NA	0.29-11	2.70

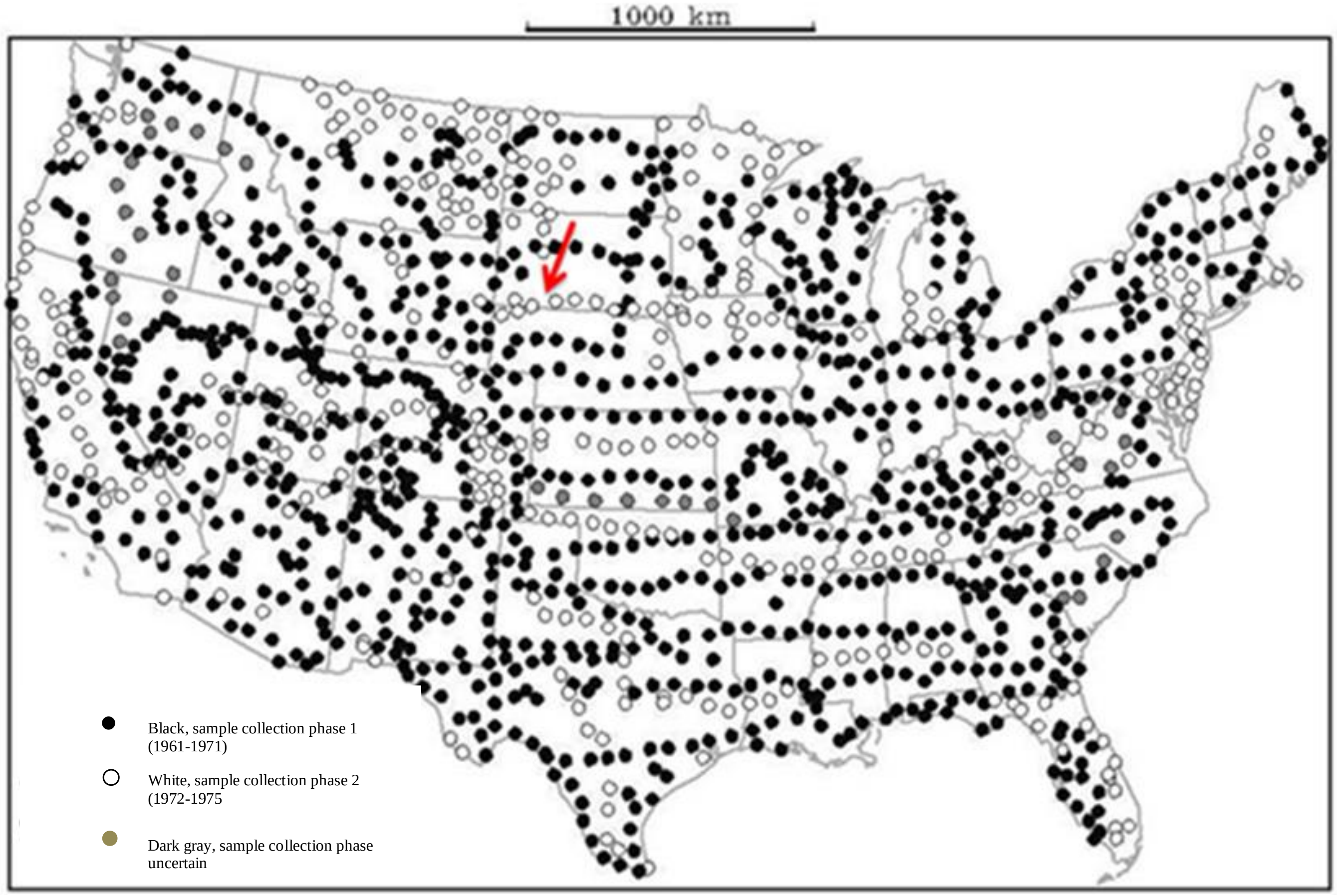


Figure 10. USGS soil sample sites for 22 elements from 1961 to 1975 with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 3).

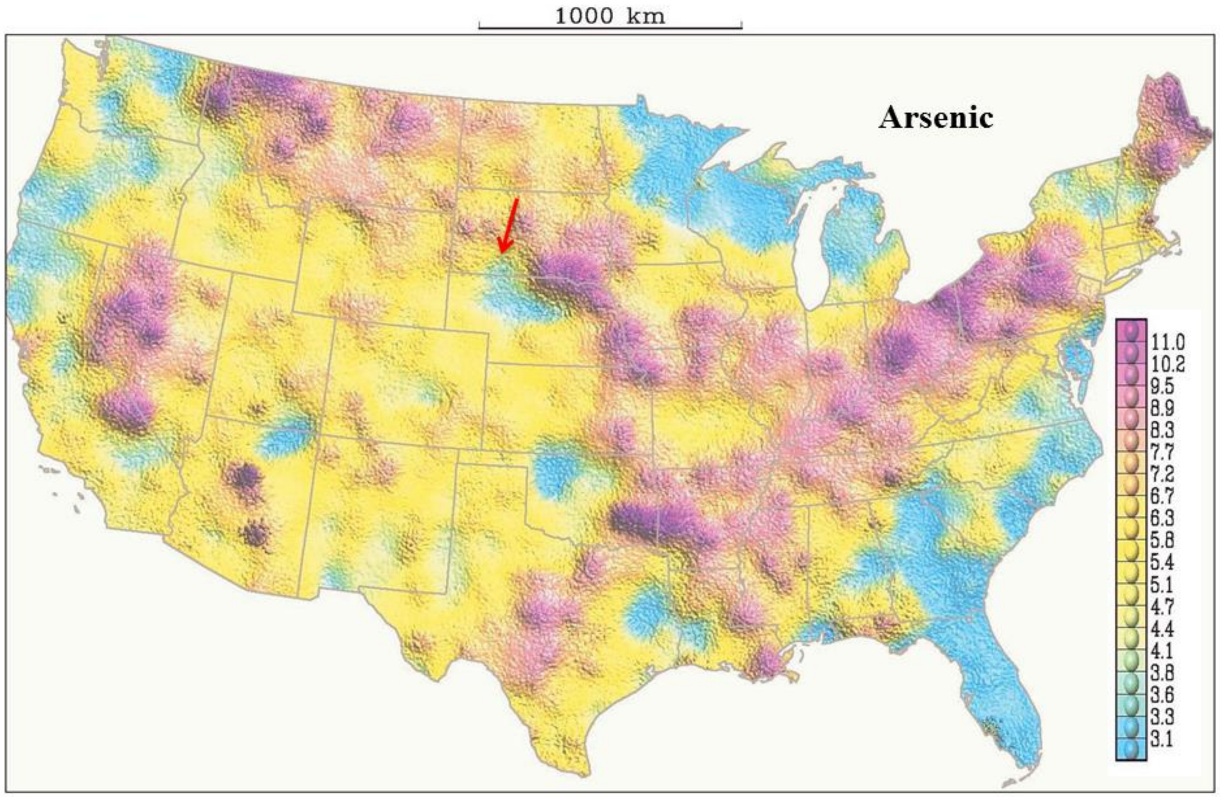


Figure 11. USGS-based arsenic distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 9).

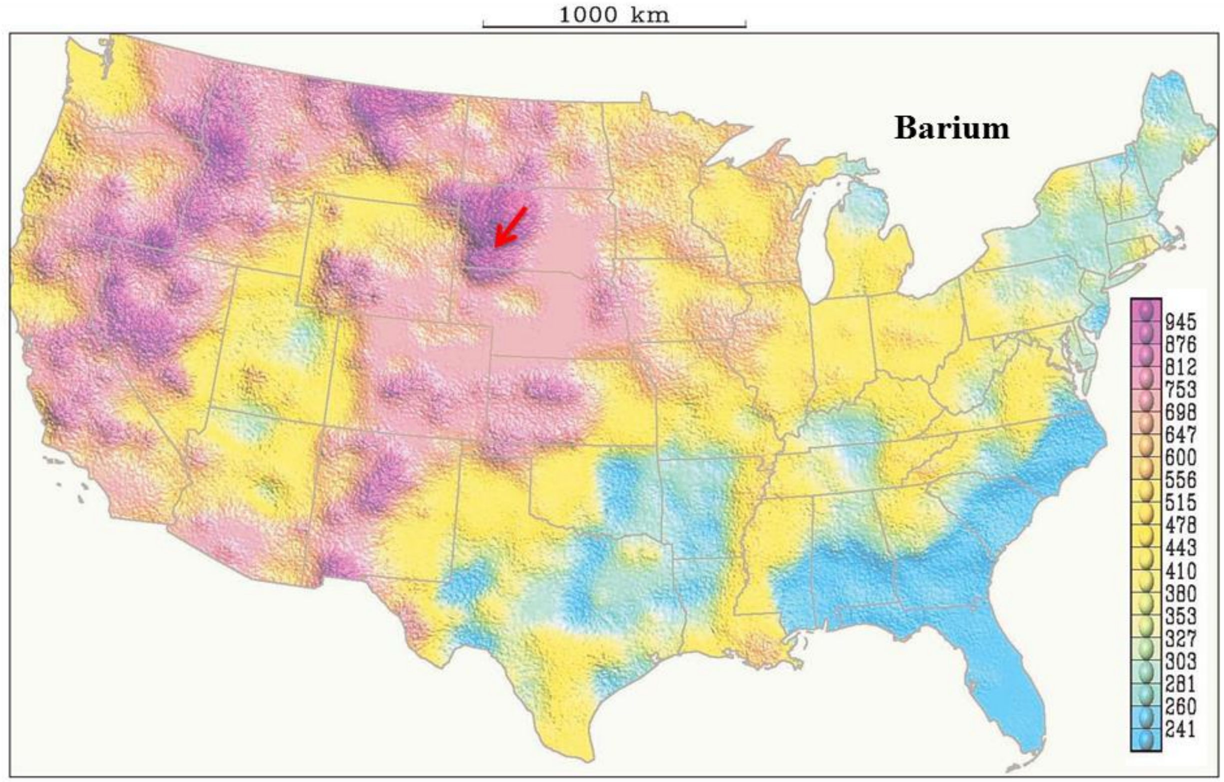


Figure 12. USGS-based barium distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 10).

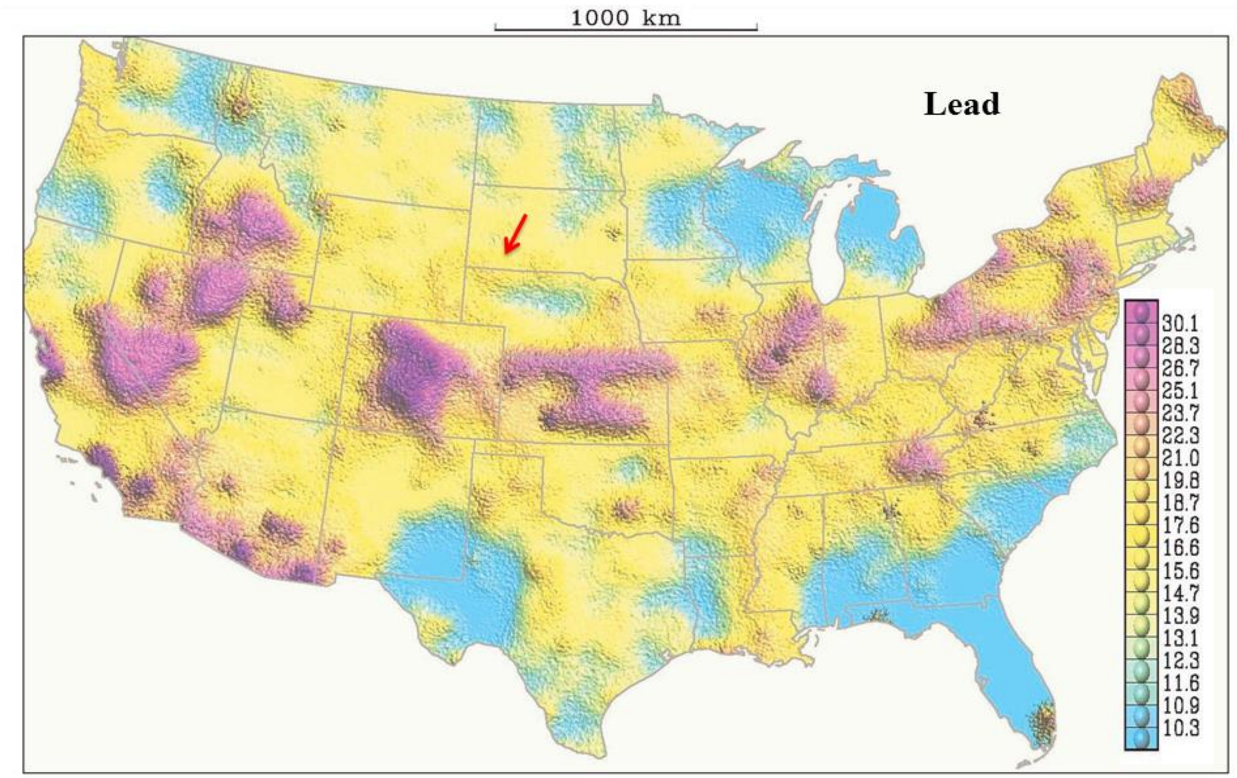


Figure 13. USGS-based lead distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 22).

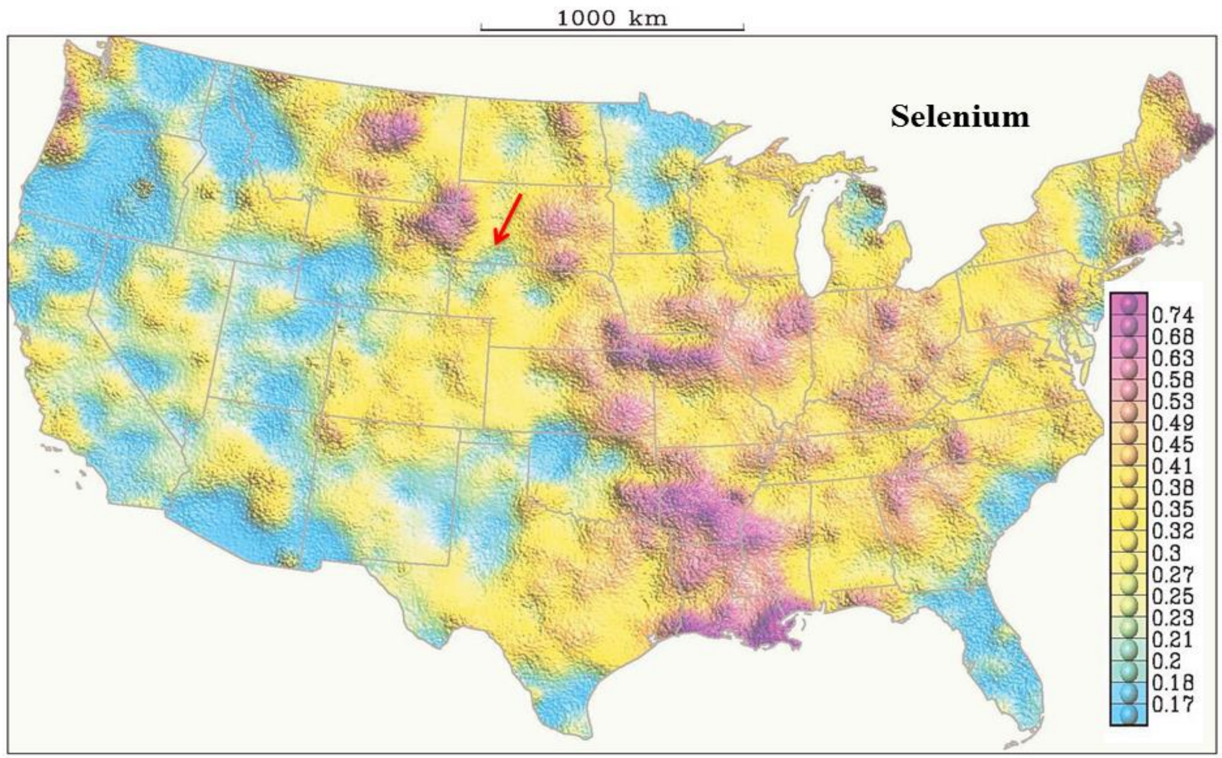


Figure 14. USGS-based selenium distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 23).

OTHER SOIL AND SEDIMENT GUIDANCE

Other sources for guidance included the Primary Remediation Goals (PRGs) of the US EPA for Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (Table 17). CERCLA guidance is for initial cleanup of Superfund sites concerning non-cancerous human health risks (unless stated), and is not meant to be used for development of stand-alone baselines. PRGs are not meant to imply a safe level of contamination (US EPA, 2012b). In addition, US EPA's CERCLA guidance lists typical exposure routes (ingestion and absorption), for contaminants, including the heavy metals in the current study, for residential land use as follows:

- Groundwater and surface water, "[i]ngestion from drinking, [i]nhalation of volatiles, and [d]ermal absorption from bathing."
- Surface water, swimming and eating fish.
- Soil, "[i]ngestion, inhalation of particulates, [i]nhalation of volatiles, [e]xposure to indoor air from soil gas, [e]xposure to ground water contaminated by soil leachate, [i]ngestion via plant, meat or dairy products, [and] [d]ermal absorption" (2012b, 4).

Table 17. Soils, US EPA preliminary remediation goals (PRGs), Superfund sites (After US EPA, 2012b).

Analyte	Screening Levels		Protection of Ground Water SSLs	
	Resident Soil mg/kg [ppm]	Key	Risk-based SSL mg/kg [ppm]	MCL-based SSL mg/kg [ppm]
Arsenic, Inorganic	0.39	c*	0.0013	0.29
Barium	15000.00	n	1200.0000	82.00
Lead and Compounds	400.00	L	NA	14.00
Selenium	390.00	n	0.4000	0.26
Uranium (Soluble Salts)	230.00	n	21.0000	14.00

Key: c*= if value were multiplied by 100, non-cancer PRGs would be exceeded; n=noncancer; L=see user guide for lead model; SSL=soil screening level; MCL=maximum contamination limit.

Another standard for soils established by the US EPA (Bastian, 1995) are regulatory limits for concentrations of heavy metals when sludge is applied. The regulations also include the maximum annual as well as the cumulative loading rates for such pollutants, as shown in Table 18.

Table 18. Sludge, US EPA maximum pollutant concentrations for heavy metals when applied to soils (After Bastian, 1995).

Element	Maximum concentration in sludge mg/kg or ppm	Maximum concentration annual pollutant loading rate kg/ha/yr	Maximum cumulative pollutant loading rate kg/ha
Arsenic	75	2	41
Lead	840	21	420
Selenium	100	5	100

Concerning sediment contaminants, the [Brazilian] National Council on the Environment (Conselho Nacional do Meio Ambiente-CONAMA, 2004) established Threshold Effect Levels (TELs) and Probable Effect Levels (PELs) for potentially toxic concentrations. The TELs are defined as “concentrations below which value are rarely associated with biological effects.” CONAMA PELS are defined as “concentrations above which value are frequently associated with biological effects” (National Council on the Environment, 2004). The standards are based on specific isotopes, rather than totals of organic and inorganic concentrations. Concerning analytes related to my study, they listed, for example, ^{75}As (a highly stable, inorganic form), ^{137}Ba, and ^{206}Pb (Table 19).

Table 19. Sediment, CONAMA (Brazil) Threshold (TEL) and Probable Effect Level (PEL) (After [Brazilian] National Council on the Environment, 2004).

Analyte	Limits of Detection ICP-MS mg/kg (ppm)	TEL mg/kg (ppm)	PEL mg/kg (ppm)
Arsenic, ^{75}As	0.026	5.900	17.000
Barium, ^{137}Ba	0.012	no reference value	no reference value
Lead, ^{206}Pb	0.045	35.000	91.300

METHODS AND MATERIALS

The methodology included selecting most of the 15 sites for which permission was obtained from local tribal government and approved by South Dakota State University (SDSU). SDSU’s Institutional Review Board (IRB), Oglala Lakota College’s (OLC’s) IRB, and the Oglala Lakota Sioux Tribe’s (OLST’s) Reservation Review Board (RRB) established certain conditions under which I conducted research. SDSU’s IRB declared the project “exempt” from review but required that I comply with regulations of IRBs/RRBs on PRR. As a result, the Oglala Lakota Sioux Tribe’s (OLST’s) Natural

Resources Regulatory Commission (NRRC) allowed the collection of plant and soil samples on the reservation in public road ditches or within strictly specified areas of tribally owned, non-leased land adjacent to paved roads. The NRRC provided aerial photographs delineating the locations where they allowed sample collecting for the research. Since the plants of interest, traditionally edible fruits, often grow along the perimeters of wooded drainages, we collaborated in examining the NRRC's aerial photos in order to request permission at likely locations. Thereby, NRRC granted permission to collect samples within reservation boundaries, where I gathered samples at Sites 1 through 10 in 2011 and at Sites 12, 14, and 15 in 2012. In addition, I collected samples at Sites 11 and 13 immediately outside reservation boundaries in 2012 (Fig. 15 and Appendix I). I revisited the sites in 2013 collecting more fruit samples to determine weights.

The plan included collecting plant and soil samples and testing them for heavy metals concentrations. The method for analysis was closed capsule microwave digestion and inductively coupled plasma optical emission spectrometry (ICP-OES).

For purposes of comparison of heavy metals concentrations from a different area, 30 sites were sampled (Fig. 16 and Appendix I) in Brookings County, SD, collecting rosehips, but not soils, in the fall of 2011. Rosehips were selected as the fruit of interest, since they comprised the only fruit consistently present at all 15 sites on and near PRR from 2011 and 2012 (Fig. 15 and 16, Appendices D-G [uranium ND], and I).

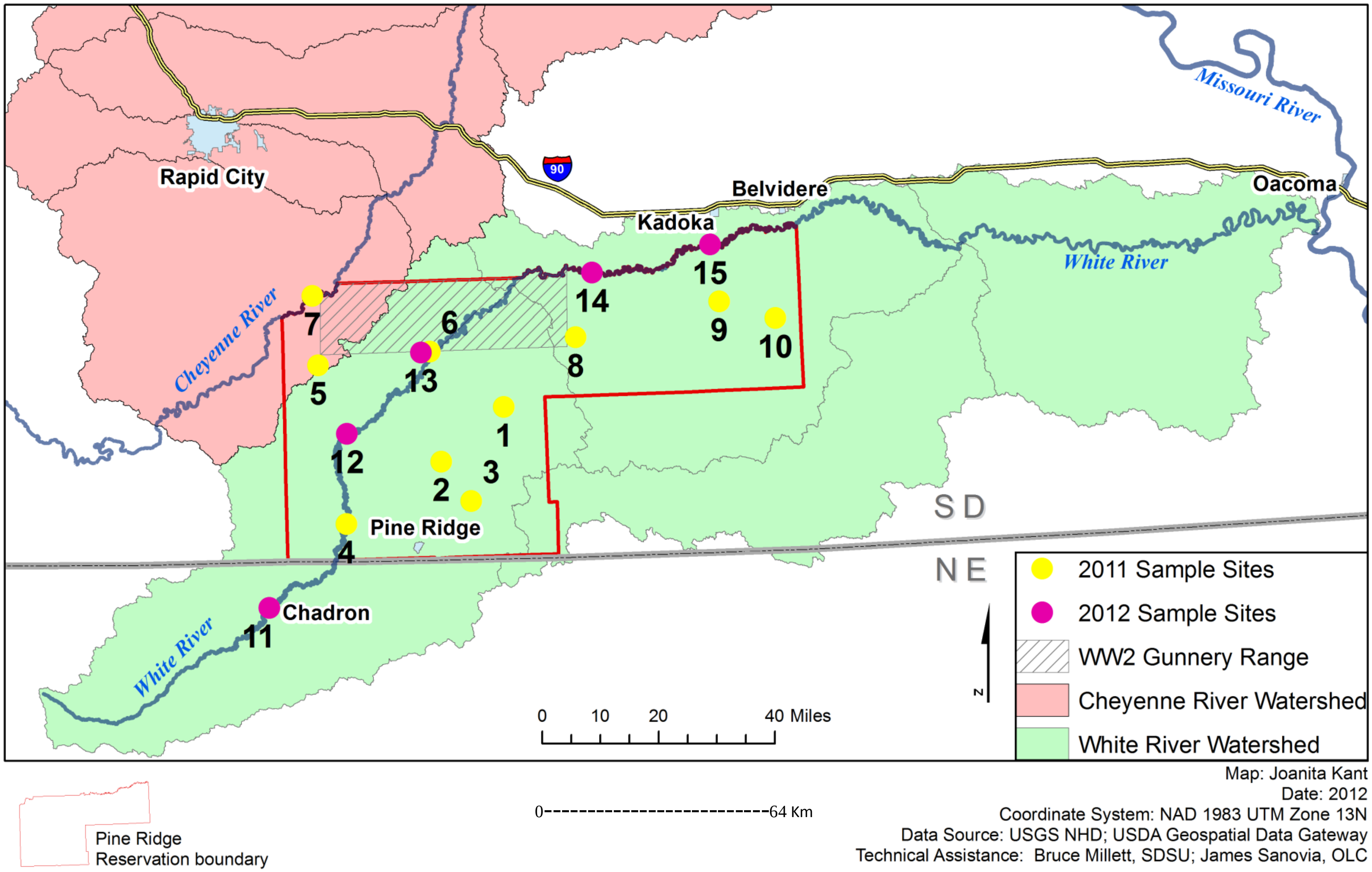


Figure 15. Map of study area and sites with boundaries of Pine Ridge Reservation in red.

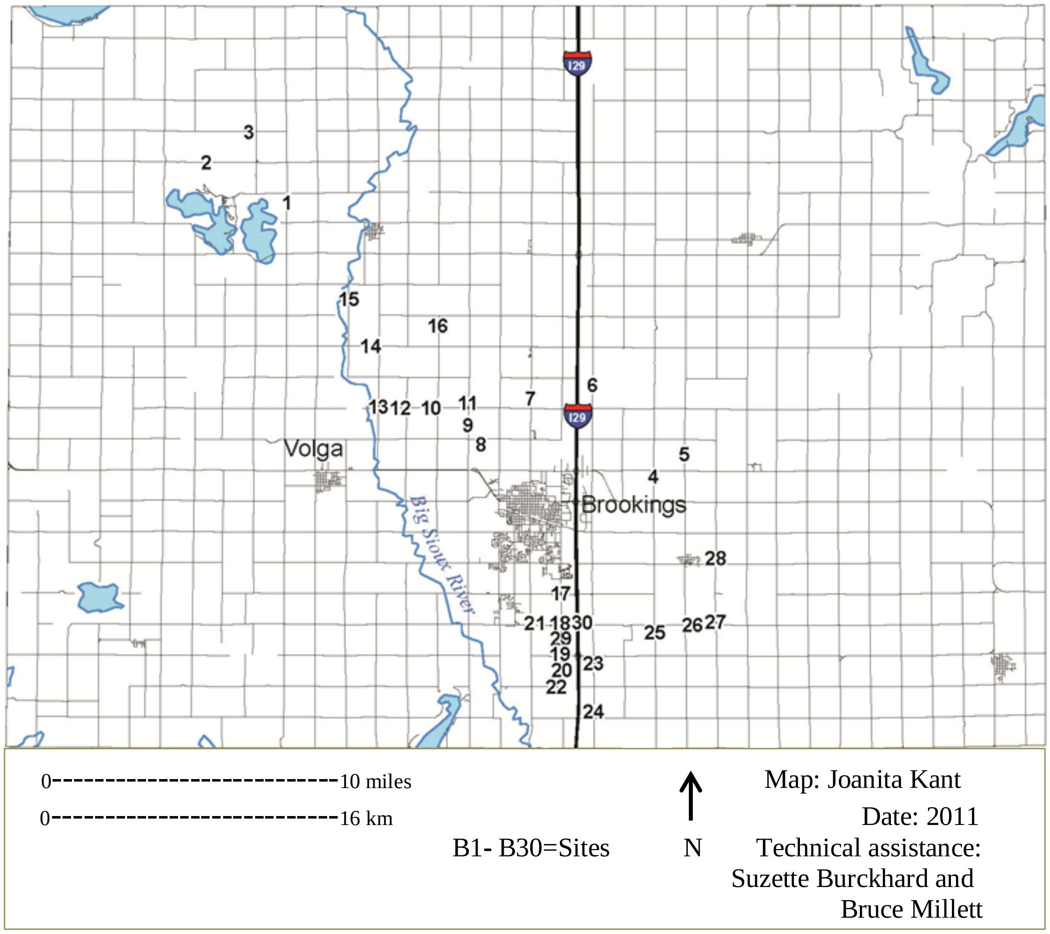


Figure 16. Map of Brookings County, SD comparative rosehip sites, 2011. Brookings sites are numbered with a “B” prefix throughout the manuscript to distinguish them from PRR sites.

DATA COLLECTION

During the 2011 summer season, the sampling plan was as follows. Sites 1 through 10 were selected ranging widely across PRR, shown in yellow in Figure 15. Samples were collected at each site including any of the traditionally edible plants of interest that were available in sufficient quantities, including buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and four species of wild roses or naturally hybridized forms. Sample plant parts of particular interest and highest priority included ripe and green fruits. Precipitation in the year 2011 was higher than average at 21.6 inches (54.864 cm), and 2012 considered by local residents to be a dry year. In comparison, the 31 year average is 19.01 inches (48.285 cm) with a 31 year range of 11.95 to 26.21 inches (30.353 to 66.573 cm) with no data available for 2012 from the Porcupine, SD reporting station on PRR (SD State Climatologist, 2013a). The plants of interest do not necessarily set fruit each year, and fruits were not abundant in either 2011 or 2012. In addition, birds, deer, and other wildlife competed for the fruits. When desirable fruit samples were not available, other plant parts were collected such as flowers, barely formed fruit, and new leafy growth. All plant parts were coded by type.

At Sites 1-10, soil samples were collected at each site in a column at ground surface near the plants of interest and at depths of 10 inches (25.4 cm), 20 inches (50.8 cm), and 30 inches (76.2 cm), with the exception of Site 9 where bedrock was reached at 20 inches (50.8 cm). Soil samples were collected from greatest depths to surface to avoid cross contamination. If plants of interest were more than 50 feet (164 m) apart at Sites 1-10, a second soil column was tested near the second group of plants. At Sites 11-15 along the White River two soil columns were tested, one at the base of the plant, "a," and another, "b," nearby at water's edge on the bank of the White River. In the fall, sites were visited again to collect more ripe fruit, particularly rosehips and grapes.

No permissions were required for collecting throughout Brookings County's comparison sites, numbered B-1 through B-30, in road ditches and public areas. Although an attempt was made to collect from all parts of the county, local wildlife had heavily grazed the plants of interest in certain areas, particularly in the floodplain of the Big

Sioux River, south of Brookings, SD. The samples collected represent the same four species of wild roses and their apparently naturally hybridized forms as those on PRR.

In the 2012 field season, a drought year, my attention turned to the White River trench that bisects the reservation with flow from southwest to northeast. Since an active uranium mine, Crow Butte, operates near the headwaters of the White River west of Crawford, Nebraska, (near Chadron, NE) a comparison of results along the river was of interest. The objective in 2012 was to compare rose plant and surface soil samples at sites along the river (Sites 11-15, shown in red in Fig. 15), with samples generally distributed across the reservation that were collected the previous year (Sites 1-10). Sites 11-15 ranged from west of Crawford and Chadron, NE, to south of Kadoka, SD (Fig. 15). Neither 2011 nor 2012 were years of abundant fruit production at the sample sites.

Wild rosehips were selected because they were the only fruit present at every site tested in the prior year's fieldwork. In addition, roses were unique, as noted along cut banks, for their deep rooting to 20 feet or more or until reaching bedrock. Therefore, roses serve as an environmental indicator with capabilities for absorption and adsorption of heavy metals in soils to greater depths than other plants of interest in the study. Selecting unique local bioindicators has been useful in other heavy metals research, as, for example, Batarseh et al., 2008).

The plan for the 2013 summer season was to collect one-cup (240 mL or 0.24 L by volume) samples of all of the fruits of interest, only to determine fresh and dry weights to coordinate with the self-reported ingestion amounts in Chapter 1. Weights were needed to compute US CDC MRLs.

Buffaloberry was not collected because it did not set fruit in 2013 at Sites 1-15, and sample quantities of ripe fruit were not sufficient for to establish weights in 2011 or 2012. Since a household measuring cup was the standard measurement that was the most meaningful term in conducting interviews, estimates of usage were given in cups and were converted to L. Fresh and dry sample weights were measured in grams.

SAMPLE PREPARATION

Plant and soil samples were collected in the field and placed in plastic Ziploc brand storage bags with labels. Plant clippers, tiling spades, scoops, and augers were thoroughly washed in three rinses of tap water and three rinses of distilled water and air dried before use. Sampling tools were dry brushed and passed through the same rinsing process during use in the field.

Plant and soil samples were placed in coolers with ice until they could be processed later in the day. The plants were divided by plant part and site and were coded, thoroughly rinsed three times in tap water and three times in distilled water, and were air dried in paper sacks. Soils were coded and air dried in paper sacks.

Once we returned to the SDSU laboratory in 2011 and 2012, plant samples were dried for three days at 60 degrees C or less (about 102 degrees F) and were ground and sieved through a 2 mm stainless steel screen. Soil samples and sediments were also oven dried, then pulverized with a mortar and pestle. They were sieved through a 2 mm stainless steel screen.

HEAVY METALS ANALYSIS

All 2011 and 2012 samples were microwave digested in closed vessels, using US EPA Method 200.7 (US EPA 2013b) for soils and plants, in CEM company's MARS 5 equipment. Some soil samples were filtered after microwave digestion, as needed, using Whatman 42 paper. Samples were then subjected to Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) in Varien, Inc., 720 Agilent equipment at the Water and Environmental Engineering Research Center (WEERC) laboratory at SDSU.

For plant samples, 0.25 g of each ground samples was placed in a microwave digestion tube. For soils samples, 0.50 g of each was pulverized, and each sieved sample was weighed and placed in a microwave digestion tube. For plant and soil samples, 10 mL of trace metal grade nitric acid (HNO_3) was added to each by pipette. For microwave and ICP spectrometry runs, each had known values of reference standards and outside source check standards with 32 known elements of interest, called lab standards. For quality control, there were spikes and duplicates, as well as laboratory blanks (Nanopure filtered deionized water with added known amounts of standards). These provided quality checks required by the methods.

Samples were microwaved, cooled, and brought to volume in flasks using Nanopure filtered deionized water. Plant samples were brought to 25 mL volume, and soils to 50 mL. Then each sample was poured into a 50 mL centrifuge tube and capped, labeled, and refrigerated until they were run through the spectrometer. Samples were poured into test tubes in racks for the spectrometer runs. The racks were set up with reference standards and check standards, as noted. The spikes for the blanks were copper or yttrium for the 2011 samples (Sites 1-10) and yttrium for 2012 (Sites 11-15) samples.

The check standards were in the 95th percentile or better. Reference standards were generally at the 90th percentile or better, and duplicates were accepted at the 80th percentile or better. US EPA Method 200.7, item number 6.10 was followed for quality control (2011a).

In 2013, one cup each of the fresh fruit samples was weighed. Each cup was then dried for four days at 60 degrees C (about 102 degrees F), and the dry weight was recorded. The weights were collected for comparison with amounts reported by interviewees in Chapter 1 in Tables 1-6.

The labware cleaning procedure was to wash the item with trace metal grade detergent solution, rinse with tap water, and soak for four hours or more in 20 per cent trace metal grade nitric acid (HNO_3) in solution with Nanopure filtered deionized water. Alternatively, the method allowed the use of nitric acid (HNO_3) or a mixture of nitric acid and trace metal grade hydrochloric acid (HC1) (1+2+9), followed by rinsing with Nanopure filtered deionized water and storing in a clean area. An acceptable alternative procedure included an extra step of rinsing with Reverse Osmosis (RO) deionized water three times and then Nanopure three times after the acid wash. Occasionally, the labware was soaked overnight in the detergent solution before the final rinses to accommodate personnel schedules.

RESULTS AND DISCUSSION

FRUITS

Figure 17 compares ICP-OES detected concentrations of heavy metals of interest for wild rose plant parts for all PRR locale sites in 2011 (Sites 1-10) and 2012 (Sites 11-15) (map, Fig.15; Appendices D-H: Figs. D-6, D7, E-6, E-7, F-6, F-7, G-6, G-7, H4, and H-5). When a site number includes an “a” or a “b,” the site has two soil sample columns because multiple species of plant samples were collected at the site, and the species were more than 50 feet (15.24 meters) apart. Plant and soil samples were linked in this scheme. A site number lacking an “a” or a “b” has only one soil column. If a site number is repeated more than once or if a site has more than one column, it simply represents another sample. (See Fig. 18 for soil concentrations presented in the same manner.)

Wild rose comprised the only plant in the study that consistently was present at every site, including over 28 per cent of the total of 98 samples of the various plants of interest. Figure 17 presents heavy metals concentration results for wild rose plant tissue samples, divided into the following categories: fruit, leaves, and “other” (a mixture of flowers and immature fruits). Heavy metals were detected in rosehip fruits more often than in other tissues of wild roses.

In comparing wild rose samples at Sites 1-10 in the 2011 series (Fig. 17), arsenic concentrations in all three plant part categories. A sample in the rosehips fruit category at Site 10 indicated the highest concentration of arsenic at 3.20 ppm, with Site 2 highest for leaves at 3.05 ppm, and only a single sample at Site 7 indicated arsenic in the “other”

Figure 17. Comparison of all wild rose sample concentrations at all PRR sites (2011 and 2012). Key: Other = mixture of flowers and immature fruit (Appendices G-H: Figs. D-6, E-6, F-6, G-6, and H-4). Backup sample 14b replaced 14a due to lab error.

category at 2.20 ppm. Results showed that arsenic in wild rose tissue was undetected at sites 4 and 8.

Continuing the comparison for wild rose tissues among Sites 1-10 (Fig. 17), results indicated that barium concentrations in all three plant tissue categories. Barium concentrations were highest at Site 1 for rosehips at over 200 ppm. Overall, barium concentrations were generally less than 100 ppm, most often below 50 ppm, and undetected at Site 9.

Lead concentrations were seldom detected in the established wild rose plant tissues for Sites 1-10 (Fig. 17) with the highest occurrence at Site 6 at 1.02 ppm. In rosehips, lead was only detected at Sites 8 and 10 at less than 0.15 ppm, and lead was undetected at Sites 2, 3, 4, 5, 7, and 9.

Selenium concentrations at Sites 1-10 (Fig. 17) in the wild rose plant tissues were highest in fruits rather than leaves or "other," with the highest concentration at Site 8 at 8.94 ppm. The next highest concentration of selenium was for the wild rose plant tissue category of "other" at Site 1 at 6.57 ppm, followed by leaves at 6.52 ppm at Site 7. Selenium was detected in wild rose tissue at every 2011 site, including Sites 1-10.

In comparing Sites 1-10 (Fig. 17), uranium was undetected in wild rose tissues at Sites 3, 4, 5, 7, 8, 9, and 10, but it was detected in each of the plant part categories for wild roses at Sites 1, 2, and 6 at 13.59 pm (fruit), 0.428 ppm (leaves), and 0.564 ppm ("other").

In the 2012 season, only rosehips (fruit) were collected along the White River, for the purpose of comparing samples with the 2011 season's Sites 1-10 rosehip samples. The 2011 sites were generally distributed across the PRR with only one site, Site 4, along the White River (map, Fig. 15). For purposes of comparison, 2012 sites were all established along the White River from upstream to downstream, with Site 11 near Crawford and Chadron, NE, (near an active uranium mine), to Site 15 south of Kadoka, SD. Site 4 (2011) was located between Sites 11 and 12 (2012) (Fig. 15).

In making the comparisons and reviewing Figure 17 by year of sampling, results showed that concentrations of the heavy metals in wild rose tissues at Sites 11-15, with the exception of selenium, were generally equal to or greater than concentrations at Sites 1-10. Site 4 results indicated much lower concentration levels of arsenic, generally comparable levels of barium, much lower levels of lead, much higher levels of selenium, and much lower levels of uranium. Site 4 was sampled after the highway and culvert were washed away by a flash flood in 2011, and the disturbance may help to explain the differences.

The levels of uranium and lead in wild rose tissues at Site 4 are low compared to other White River Sites (Fig. 17). Many variables influence uptake of heavy metals, including uranium, a key difference in comparing uranium (and other heavy metals of interest) concentrations at Site 4 with concentrations in wild rosehips at Sites 11-15 may be precipitation differences in 2011 and 2012 a wet year and a drought year, respectively.

Site 1 is conspicuous for elevated levels in three of the five heavy metals of interest, including barium, selenium, and uranium in wild rose tissues.

Table 20 includes averages and ranges of concentrations of heavy metals in fruits of interest. The exception is buffaloberry, where only one fruit sample was collected, as already noted.

US CDC MRL exposures (Table 21) were determined for the heavy metals of interest in the fruits of interest, with the exception of buffaloberry, since buffaloberry did not set fruit in 2013 when samples were taken to obtain wet and dry weights that were essential for MRL calculations (Appendix K, Table K-1). In addition, the study included only 1 buffaloberry fruit sample because of lack of availability of the fruit in 2011 and 2012. Buffaloberries remained in the study because there were 7 samples of leaves and one sample of "other" (immature fruit and flower parts) in which heavy metals were detected. Those samples remain useful for this screening study in establishing a baseline against which other data may be compared in the future.

Reported exposure quantities in Chapter 1 were used to estimate yearly intake of the fruits in cups (0.24 L volume) in column C, with conversions of fresh "wet" weight to dry weight in column D. Heavy metals concentrations detected in the other fruits of interest on and near PRR at 15 sites were analyzed to find arithmetic means and ranges in mg as shown in Table 21 (Table K-1 in columns G and H). Other factors used in calculations included standard body weight of 55 kg, and 364 or 365 days of chronic exposure. Since a 365-day exposure category was not set for uranium by US CDC, the next best available choice their category of up to 364 days.

In Table 21 (Table K-1), US CDC conversions were calculated in column L as mg of heavy metal concentration in dried fruit multiplied by kg of body weight multiplied by 365 days (or 364 in the case of uranium). Then comparisons were made to see if a potential yearly "dose" exceeded the MRL. For example, the US CDC MRL formula is mg of heavy metal/kg of body weight/days of exposure; thus, for buffalo currant and arsenic, the first line of Table K-1 equals 6.0225 mg, the maximum allowable yearly dose for this standard, as below,

$$\frac{0.0003\, mg\ As}{kg\ \cdot day} \times 55\ kg\ \times 365\ \frac{days}{year}\ = 6.0225\ \frac{mg\ As}{year\ .}$$

The potential yearly dose from Chapter 1 data for arsenic concentration in buffalo currant equals 2.7273 mg, based on the arithmetic mean, as below,

$$\frac{100\ cups}{year} \times 0.02117\ \ \frac{kg\ dry\ fruit}{cup} \times 1.288\ \frac{mg\ As}{kg\ dry\ fruit} = 2.73\ \frac{mg\ As}{year\ .}$$

The potential yearly dose based on the maximum concentration observed equals 5.4555 mg, as below,

$$\frac{100\ cups}{year} \times 0.02117\ \ \frac{kg\ dry\ fruit}{cup} \times 2.5770\ \frac{mg\ As}{kg\ dry\ fruit} = 5.46\ \frac{mg\ As}{year\ .}$$

Thus, in this case, since 6.0225 mg exceeds 2.7273 mg and 5.4555 mg, both doses are below the MRL standard.

In Table 21 (Appendix K, Table K-1), calculations that exceeded MRLs are marked in red and yellow.

Final results were extracted from Table K-1 and summarized in Table 21, emphasizing US CDC MRLs. Reported exposures were calculated for the mean and the highest score in the range to determine a "dose" that exceeded neither, then checking to see how many individuals in certain categories still exceeded that dose (shown in yellow in Table 21). Exposure to heavy metals potentially exceeded MRLs for some fruits. In particular, those included arsenic for 4 persons (12.5 per cent) consuming chokecherries at a maximum of 16 cups per year. In addition, those included arsenic for 1 person (3 per cent) consuming wild rosehips at a maximum of 16 cups per year. Also potentially exceeding US CDC MRLs for uranium in particular were 2 persons (6 per cent) at a maximum of 32 cups per year of wild plums, and for uranium, four persons (12.5 per cent) at a maximum of 2 cups of wild rosehips per year of wild rosehips.

The potential for exceeding MRLs increases when multiple fruits are ingested by an individual creating a cumulative total as the yearly dose. It is important to keep in mind that the standard for uranium MRLs is "uranium soluble salts," and the study only detected "total uranium," so that identical comparisons could not be made. While using the fruits may increase exposure to heavy metals in the PRR community, the risk of exceeding US CDC MRLs from use of these foods, alone, is relatively low (Table 21). Further studies, comparing equivalent analytes, as well as total dietary studies could provide a clearer view of true uptake potential.

Comparisons of concentrations of heavy metals detected in PRR area rosehips with those from 30 sites (Sites B-1-B30, 2011) in Brookings County, SD are presented in Table 22 with calculations in Appendix K, Table K-2. Results indicated that heavy metals concentrations were generally lower in the Brookings County samples with the exception of lead and selenium which were comparable or slightly higher. The highest concentrations for individual samples for lead and selenium in Brookings County may be outliers. However, increased lead concentrations in Brookings County may be related to greater population density and the use of leaded gasoline before the advent of emissions controls on vehicles.

Table 20. Fruit, ranges and arithmetic means for heavy metals concentrations, Sites 1-15, near and on PRR. Calculations do not include for buffaloberry, since only one fruit sample was collected, although other buffaloberry plant tissues are included in the study.

Fruit	Heavy metal	Only one sample mg/kg	Arithmetic mean mg/kg	Range (ND=none detected) mg/kg	ND ratio	ND %
Buffaloberry	arsenic	0.68	NA	NA	NA	NA
	barium	27.39	NA	NA	NA	NA
	lead	ND	NA	NA	NA	NA
	selenium	5.72	NA	NA	NA	NA
	uranium	ND	NA	NA	NA	NA
Buffalo currant	arsenic		1.29	ND-2.58	1 of 2	50
	barium		10.15	4.97-15.34	0 of 2	0
	lead		ND	ND	2 of 2	100
	selenium		2.26	2.21-2.30	0 of 2	0
	uranium		ND	ND	2 of 2	100
Chokecherry	arsenic		0.32	ND-1.93	6 of 9	67
	barium		27.39	ND-58.71	1 of 9	11
	lead		0.01	ND-0.07	7 of 9	78
	selenium		2.84	ND-7.42	3 of 9	33
	uranium		ND	ND	9 of 9	100
Wild grape	arsenic		0.42	ND-1.11	2 of 4	50
	barium		54.77	31.05-77.23	0 of 4	0
	lead		1.76	ND-0.29	3 of 4	75
	selenium		1.76	ND-4.12	2 of 4	50
	uranium		ND	ND	4 of 4	100
Wild plum	arsenic		0.26	ND-1.03	3 of 4	75
	barium		69.19	23.45-178.24	0 of 4	0
	lead		0.00	ND-0.01	0 of 4	0
	selenium		5.14	2.35-8.90	0 of 4	0
	uranium		0.72	ND-2.90	3 of 4	75
Wild rose	arsenic		0.41	ND-3.20	17 of 27	63
	barium		34.94	ND-211.51	3 of 27	11
	lead		0.06	ND-0.69	21 of 27	78
	selenium		1.94	ND-8.94	6 of 27	22
	uranium		1.46	ND-13.59	21 of 27	78

Table 21. Fruit, US CDC MRL calculations for heavy metals, Sites 1-15 on and near PRR.

A	B	C	D	E	F	G	H	I
Fruit	**Heavy metal species in US CDC standard**	**Number of cups per year, cups fresh, volume (1 c.- 0.24L) per year, cups**	**Yearly "dose" based on arithmetic mean mg**	**Yearly "dose" based on highest score in range mg**	**Body weight standard kg**	**Days of chronic oral use**	**Exposure in mgs of heavy metal/ kg of body weight/ 365 days (except uranium/365 days)**	**# persons/% above lowest MRL dosage***
Buffalo currant	arsenic	100	2.73	5.46	55	365	6.02	
	barium soluble salts	100	21.50	32.48	55	365	4015.00	
	selenium	100	4.78	4.86	55	365	100.38	
	uranium soluble salts	100	ND	ND	55	364	4.00	
Chokecherry	arsenic	150	2.47	14.96	55	365	6.02	
	arsenic	80	1.32	7.98	55	365	6.02	
	arsenic*	16	0.26	1.60	55	365	6.02	#4/ 12.5%
	barium soluble salts	150	212.00	454.50	55	365	4015.00	
	selenium	150	21.98	57.42	55	365	100.38	
	uranium soluble salts	150	ND	ND	55	364	4.00	
Wild grape	arsenic	80	1.24	3.28	55	365	6.02	
	barium soluble salts	80	161.95	228.34	55	365	4015.00	
	selenium	80	5.19	12.18	55	365	100.38	
	uranium soluble salts	80	ND	ND	55	364	4.00	
Wild plum	arsenic	150	0.96	3.83	55	365	6.02	
	barium soluble salts	150	256.34	660.36	55	365	4015.00	
	selenium	150	19.05	32.96	55	365	100.38	
	uranium soluble salts	150	2.68	10.72	55	364	4.00	
	uranium soluble salts	80	1.43	5.72	55	364	4.00	
	uranium soluble salts*	32	0.57	2.29	55	364	4.00	#2 / 6%
Wild rose	arsenic	64	1.40	11.00	55	365	6.02	
	arsenic*	16	0.35	2.75	55	365	6.02	#1 / 3%
	barium soluble salts	64	119.96	726.09	55	365	4015.00	
	selenium	64	46.64	30.70	55	365	100.38	
	uranium soluble salts	64	5.01	46.64	55	364	4.00	
	uranium soluble salts	16	1.25	11.66	55	364	4.00	
	uranium soluble salts	10	0.78	7.29	55	364	4.00	
	uranium soluble salts	6	0.47	4.37	55	364	4.00	
	uranium soluble salts*	2	0.16	1.46	55	364	4.00	#4 / 12.5%

Key: red= yearly "dose" in mgs where interviewees exceeded mean or highest score in reported range; yellow*= yearly "dose" (Column C) where some interviewees still exceeded the MRL dosage (Column H), with numbers/percentages of interviewees represented in that category, Column I; and Column H=do not exceed level based on MRL.

Table 22. Wild Rosehips comparison of heavy metals concentrations, on and near PRR Sites 1-15; and Brookings County, SD, Sites B1 through B30 (see Appendix K, Table K-2 for calculations). Key*= possible outliers.

Element	Location	Range (ND=none detected) mg/kg	Arithmetic mean mg/kg	ND ratio	ND %
arsenic	PRR study area	ND-3.20	0.41	17 of 27	63
arsenic	Brookings Co., SD	ND-2.56	0.26	24 of 30	80
barium	PRR study area	ND-211.51	34.94	3 of 27	11
barium	Brookings Co., SD	0.45-23.31	6.94	0 of 30	0
lead	PRR study area	ND-0.69	0.06	21 of 27	78
lead	Brookings Co., SD	ND-1.67*	0.08	24 of 30	80
selenium	PRR study area	ND-8.94	1.94	6 of 27	22
selenium	Brookings Co., SD	ND-10.25*	2.73	6 of 30	20
uranium	PRR study area	ND-13.59	1.46	21 of 27	78
uranium	Brookings Co., SD	ND	ND	30 of 30	100

Johnson and Ademoyero warn that risk assessments need to be improved and that creating risk assessments based on inadequate data should be avoided, as follows:

> In the absence of adequate scientific information, a risk assessment should not be done. All risk assessments acquire a certain degree of permanency, and those that are developed using less-than-adequate database are difficult to retract and lead to diminished credibility of the risk assessor. Rather than developing a risk assessment predicated on an insecure foundation, it is better to identify and conduct the key research needed to perform a specific risk assessment" (1994, 10-11).

Therefore, in heeding their advice, the current study purports to add to the overall database of detected levels of selected heavy metals and routes and amounts of ingestion of traditionally edible fruits in certain populations, determining if cultural norms tend to increase exposure to naturally occurring heavy metals. Specific risk assessment for disease, per se, is beyond the scope of the current study. The comparisons to US CDC MRLs that follow for arsenic, barium, selenium, and uranium are meant to guide health professionals concerning where to look more closely. In comparing lead concentrations to standards set by WHO/FAO and FSANZ, the same applies.

Concentrations of heavy metals in fruits were compared to US CDC MRLs, with the exception of lead, since no lead MRL has been established. The US CDC does not set levels because they have concluded that there is no "safe" level, and that might be implied by setting an MRL. Lead exposure should be kept as low as possible. Lead is considered later and is compared to other standards. Calculations began with the highest number of cups reported by an individual as reported in Chapter 1. Buffaloberry was not included because it did not set fruit in 2013, the year fruits were collected for weighing. Collecting fruit for the purposes of establishing weights was delayed in 2011 and 2012 because fruit production was limited in each of those years, probably due to weather and lack of pollination.

When calculating MRLs based on arithmetic means of heavy metals concentrations in fruit, Sites 1-15 were below the standard based on maximum cups reported in interviews, with one exception. That exception was for uranium in wild rosehips on and near PRR based on a maximum reported use of 64 cups per year. It is important to note that the current study measured total uranium, and the US CDC standard is for "uranium soluble salts." The yearly mean dose reported in interviews in Chapter 1 at 5.0091 mg was only slightly higher than the MRL of 4.0040 mg. for uranium soluble salts. Thus, it is possible that samples could fall within MRL limits if equivalents could be compared. However, a maximum of 16 cups (3.79 L) of wild rosehips could be ingested to remain below the MRL.

A second calculation was made, using the most extreme score of detected concentrations of heavy metals in fruits, calculating MRLs based on the highest scores in each range. The point was to create the worst case scenario for ingesting heavy metals based on samples in the study, however unlikely.

When calculating MRLs based on the highest score in the ranges of heavy metals concentrations in fruit, only arsenic in chokecherries and wild rosehips, and uranium soluble salts were exceeded for wild plum and wild rosehips. MRLs were exceeded for arsenic at 80 cups (18.93 L) per year of chokecherries, with a maximum of 150 cups (35.49 L) reported by an interviewee in Chapter 1. Also for arsenic, MRLs were exceeded at 64 cups (15.14 L) (the maximum reported) for wild rosehips. MRLs were exceeded for uranium soluble salts at 80 cups per year for wild plums, with a maximum of 150 cups (35.49 L) reported. MRLs were exceeded for uranium soluble salts (although total uranium and not uranium soluble salts was measured in the fruits) at 6 cups per year for wild rosehips, with a maximum of 64 cups (15.14 L) reported. Despite those excesses, 4 of 32 persons ingesting arsenic in chokecherries and 1 of 32 persons ingesting arsenic in wild rosehips exceeded the MRLs. In addition, 2 persons ingesting uranium soluble salts in wild plums and 4 persons ingesting uranium soluble salts in wild rosehips exceeded the MRLs. The risk, therefore, based on US CDC MRLs, is low when basing calculations on the highest score in the range of values for heavy metals in traditionally edible fruits.

For those individuals consuming several or all of the fruit types, the cumulative load of each of the heavy metals could potentially exceed the MRLs for a few based on the highest score in the range. For example, the MRLs may be exceeded for arsenic and uranium if the maximum amount reported of each of the fruits were ingested per year. The load would be calculated by adding the "dose" per year for arsenic from each type of fruit and checking to see if it exceeds the total MRL allowable. For example, the yearly maximum dose for arsenic in buffalo currant based on the arithmetic mean is 2.73 mg; and for chokecherry, 2.47 mg; and for wild grape, 1.24 mg; and for wild plum 0.96 mg; and for wild rose, 1.40 mg; for a total of 8.8 mg, while the MRL is 6.02 mg. Such calculations might suggest looking more closely at ingestion of fruits at such levels as 100 cups (23.66 L) for buffalo currant, 150 cups (35.49 L) for chokecherry, 80 cups (18.93 L) for wild grapes, 150 cups (35.49 L) for wild plum, and 64 cups (15.14 L) for wild rosehips (Table 21), especially in combination.

The wild rosehips results for Sites 1-15 on and near PRR were compared to wild rosehip results at Sites B1-B30 in Brookings County (Table 22). Calculations were determined based on arithmetic means, as above, and all samples were lower than MRLs. However, when calculations were based on the highest score in the range, arsenic (possibly an outlier) exceeded the MRL standard of 6.0225 mg with a result of 8.7880 mg, again representing an unlikely worst case scenario. In addition, the selenium range to 35.18 mg is likely an outlier with the next lower score at 6.810 mg. With that in mind, generally, all means and ranges were substantially lower than those for PRR (Table 21, and Appendices K and I: Tables K-2, and I-5).

WHO/FAO Codex Alimentarius (2000) set a lead concentration for maximum level permitted (ML) at 0.20 mg/kg for berries and small fruit and 0.10 mg/kg for pome and stone fruits with lower levels for infant foods. In addition, FSANZ (2013) set the lead ML for fruit at 0.10 mg/kg. Results indicated that for lead concentration levels detected in all fruit samples at Sites 1-15 in the PRR locale, 5 of 47 (11 per cent) exceeded 0.10 mg/kg, and 4 of 47 (8.5 per cent) exceeded 0.20 mg/kg (Appendix I, Table I-1 and I-2). By way of comparison, 5 of 30 (17 per cent) wild rosehip samples in Brookings County exceeded 0.10 mg/kg, and 3 of 30 (10 per cent) exceeded 0.20 mg/kg (Appendix I, Table I-5).

While the US EPA (2013a) has set primary drinking water standards for lead as a "treatment technique," (TT), meaning that action is required if samples are consistently above certain levels, US governmental agencies have not set levels for food, with the exception of bottled water (US FDA 2009a). Food is handled on a case by case basis.

The US CDC (2007c) has not set lead standards because they do not want to convey that any level of lead is "safe," especially for vulnerable populations such as fetuses, infants, children, the malnourished, and those in poor health, among others. Their position is simply that lead needs to be kept at the lowest possible levels that are economically feasible.

SOILS

Figure 18 compares ICP-OES detected concentrations of heavy metals of interest in soils at Sites 1-10 on PRR in 2011 at the surface, 10, 20, and 30 inches (surface, 25.4, 50.8, and 76.2 cm) levels, and at Sites 11-15 on and near PRR in 2012, at the surface (also see Figs. D-8, E-8, F-8, G-9, and H-6). The purpose of testing Sites 11-15 in 2012 was to determine if concentrations of heavy metals in soils at sites along the White River varied from those distributed across PRR, including Site 4 along the White River.

The variability of heavy metals concentrations at the same site is apparent in comparing detected levels at “a” and “b” paired sites, such as 4a and 4 b, for example. Most “a” and “b” soil columns are within 100 feet (30.48 meters) of one another. As noted, a second soil column was established only if necessary as in cases where plants of interest were more than 50 feet (15.24 meters) from soil column “a” at each site (Fig. 18).

Year 2012 White River Sites 11-15 were generally higher in concentrations of arsenic in soils at the surface level than other PRR sites with the exception of White River Site 4. Compared to the 2012 White River sites, the 2011 sites were generally comparable in soil concentrations of barium and lead at the surface level but much lower in selenium and much higher in uranium, with the exception of Site 8, with the highest concentration for uranium of any site in the entire study at 35.94 ppm.

In comparison with one another, Sites 1-10 from the 2011 series, revealed arsenic concentrations in soils at all sites but not at all depths in the study. Arsenic concentrations in soils were highest at Site 4 at 12.30 ppm at a depth of 50.8 cm. Concentrations of arsenic in soils were generally below 8 ppm.

Continuing the comparison, soil concentrations of barium were detectable in all samples at Sites 1-10. Site 3 had the highest concentration of barium at about 1,300 ppm at a depth of 76.2 cm. Barium concentrations in soils were reported at all sites and most depths, usually in concentrations below 400 ppm, but increasing to over 600 ppm at sites 2, 4, 9, and 10. In general, most soil concentrations of barium were well below 800 ppm.

Lead concentrations detected in all soil samples at Sites 1-10 indicated that the highest concentration of lead was at Site 4 on the White River, at 28.44 ppm at a depth of

50.8 cm. The next highest concentrations were at the surface level at Sites 1, 2, 4, 5, 6 and 9 from about 10 to 20 ppm.

Selenium was detected in all soil samples for Sites 1-10, ranging from below 2 ppm at a few sites to a high of more than 12 ppm at Sites 3 and 4. Potential bioaccumulation of selenium in plant tissue is discussed elsewhere.

Although detected in most soil samples at Sites 1-10 (2011), uranium showed variable concentrations at all depths with the largest concentration of 29.35 ppm at a depth of 20 inches (50.8 cm) at Site 7, and 35.94 ppm at the surface level at Site 8. In general, uranium concentrations were below 32 for Sites 1-10 (Fig. 18).

Figure 18. Comparison of all soil sample concentrations at all PRR sites (2011-2012). Site 9 lacks 76.2 cm sampling because of bedrock at that level (Appendices D-H: Figs. D-8, E-8, F-8, G-9, and H-6). Backup sample 14b replaced 14a due to lab error.

SOILS COMPARED TO USGS BASELINES

Soil concentration results from the current study were also compared with results from two USGS baselines for the conterminous United States. For both, samples were collected by USGS teams from 1961 to 1975 by Shacklette and others (Shacklette et al., 1971; Boerngen and Shacklette, 1981; and Shacklette and Boerngen, 1984) and the data was later reworked by Gustavsson et al., 2001.

Since the USGS samples were collected at a depth of 24 cm, samples from the current study at the closest depth, 25.4 cm, were extracted for comparison (Table 23). In addition, all soil sample results from the current study, collected in the summers of 2011 and 2012, were extracted for comparison (surface, 25.4 cm, 50.8 cm, and 76.2 cm) for all 15 sites (Appendix I, Tables I-3 and I-4). Arithmetic means and ranges were determined, and comparisons are presented in Table 24.

Table 23. Soil sample concentrations from PRR, depth of 25.4 cm, 2011.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm
1a	3.55	257.11	7.67	7.33	5.08
1b	2.80	224.02	9.01	2.05	11.16
2a	1.31	220.40	8.74	6.65	4.97
2b	2.67	216.05	7.34	8.63	0.00
3a	0.27	182.35	6.80	12.52	7.71
3b	0.52	210.72	5.84	3.86	0.00
4a	6.30	312.74	8.66	3.30	15.35
4b	2.74	320.25	8.60	11.58	10.22
5	2.18	189.82	13.17	5.31	16.96
6	5.73	253.55	10.45	9.66	13.83
7a	4.30	139.53	6.35	9.73	1.90
7b	1.89	176.20	3.91	6.93	1.28
8a	6.06	247.69	6.04	8.31	6.20
8b	5.01	254.48	7.13	9.94	27.95
9	5.14	458.75	12.51	5.19	18.25
10	0.64	619.23	11.09	6.78	16.40
arith. mean	3.19	267.68	8.33	7.36	9.83
range	0.27-6.30	140-619	3.91-13.17	2.05-12.52	0-27.95
std. dev.	1.97	115.64	2.42	2.87	7.64
# ND	0	0	0	0	2
% ND	0	0	0	0	12.5

Table 24. Soils, USGS baseline concentration comparisons with PRR locale Sites 1-10 at similar depths and at various depths (gray for emphasis of arithmetic mean and range comparisons at similar depths, as distinguished from median-derived and Bootstrap-determined baselines or other depths).

	A	B	C	D	E	F	G	H
Element	USA conterminous range at 24 cm	PPR range at 24 cm	USA conterminous		PRR locale			
			range at 24 cm	arithmetic mean at 24 cm	range at 25.4 cm	arithmetic mean at 25.4 cm	range at surface, 25.4, 50.8, and 76.2 cm	arithmetic mean at surface 25.4, 50.8, and 76.2 cm
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Arsenic	3.10-11	4-8	0.10-97	7.20	0.27-6.29	3.19	ND-12.30	3.32
Barium	241-945	800-945	10-5,000	580	139.53-619.23	267.68	139.5-1311.9	308.49
Lead	10.30-30.10	15-20	<10-700	19	3.91-13.17	8.33	3.91-28.44	8.98
Selenium	0.17-0.74	0.17-0.41	<0.10-4.30	0.39	2.05-12.52	7.36	ND-12.69	6.17-7.03
Uranium	NA	NA	0.29-11	2.70	ND-27.94	9.83	ND-35.94	13.46

Key: A=1961-1975, weighted-median and Bootstrap-based by Gustavsson et al. (2001) representing about 1,318-1,323 statistically reworked samples after Shacklette and Boerngen (1984) and others. B=1961-1975, weighted median and Bootstrap based, PRR data extracted by Kant from Gustavsson et al., 2001, after Shacklette and Boerngen (1984) and others, representing about four sites. C and D=1961-1975, representing 1,318-1,323 samples from Shacklette and Boerngen (1984) and others. E and F=Kant, 2011, representing 16 samples, Sites 1-10. F=Kant, 2011, representing 16 samples, Sites 1-10. G and H= Kant, 2011-2012, representing 73 samples, Sites 1-15.

USGS baseline studies were selected for comparisons with soils in the current study, although US EPA PRGs, US EPA sludge standards, and Brazilian CONAMA sediment standards were presented in the literature review to show the variety of guidance concerning soils that is available for researchers.

Of the heavy metals of interest in this study, average soil concentrations of arsenic, barium, and lead (at depths of about 24 to 25 cm) are lower than baselines for the conterminous United States established by Shacklette and Boerngen (1984) in USGS studies (Table 24). However, average soil concentrations of selenium and uranium are much higher, as much as 18 times for selenium and 3.6 times for uranium for samples from the PRR locale (Table 24, columns C-F).

While it is of interest to compare current study results with the soil baselines established by Gustavsson et al. (2001), their results were based on weighted moving medians that were statistically bootstrapped (Table 24, column A). Data in the current study is based on ranges and arithmetic means; thus, comparisons with the baselines established by Gustavsson et al. are not as useful for comparisons as the arithmetic means and actual ranges for the conterminous United States estimated by Shacklette and Boerngen (1984) (Table 24, columns C-D).

The maps by Gustavsson et al. (2001) were relevant for comparison (Figures 11-14), since they depict, by color coding, relative concentrations of arsenic, barium, lead, and selenium (not including uranium) distribution in soils for the conterminous United States. Their maps by Gustavsson et al. (2001) indicate that for the PRR area, arsenic is generally in the low range, barium in the high range, lead in the medium range, and selenium in the low range.

The low selenium determination for the PRR locale as shown on the map (Fig.14) by Gustavsson et al. (2001) is likely an anomaly caused by statistical procedures. In checking the maps of Shacklette and others (1984), upon which the Gustavsson et al. maps were based, results for the PRR locale were probably based about four sample sites on PRR, statistically manipulated to the number of samples in the original study when the data was reworked. Thus, the PRR locale, known for its selenium indicating plants, escaped detection. The Gustavsson maps remain valuable as the most comprehensive baseline available for the conterminous United States, although they may have limited precision at the local scale.

In Figure 14, the selenium distribution map by Gustavvson et al. (2001), with its statistically smoothed data, some of the highest levels of selenium in the conterminous United States are indicated in soils northwest of PRR, in the Black Hills, northeast Wyoming, and southwest Montana (median-weighted and bootstrapped ranging from 0.17 to 0.74 ppm). However, in the current study, selenium concentrations in soils, on and near PRR ranged from none detected to 12.69 ppm with an average of approximately 6 to 7 ppm at a depth of 25.4 cm (Table 24). Shacklette and Boerngen (1984) reported a range of <0.10 to 4.30 ppm with an arithmetic mean of 0.39 ppm for the conterminous United States (Table 24). Thus, by comparison, the PRR locale is a place of high concentrations of selenium.

Uranium was not included when Gustavvson et al. (2001) revised and statistically manipulated the data of Shacklette and others. However, Shacklette and Boerngen (1984) originally reported an actual statistical range (not a modified median as in Gustavvson et al. 2001) of uranium concentration in soils for the conterminous United

States at 0.29 to 11 ppm and an arithmetic mean of 2.70 ppm (Table 24, column D). Uranium results from the current study, when including soil samples at a depth of 25.4 cm ranged from none detected to 27.94 ppm with an arithmetic mean of 9.83 ppm (Table 24, columns E-F). Thus, uranium concentrations in soils on and near PRR are much higher than the maximum range reported by Shacklette and Boerngen (1984) for the conterminous United States. For the PRR locale, results at 25.4 cm indicated that the highest concentration in the range was more than twice that reported by Shacklette and Boerngen (1984) for the conterminous United States, and the PRR arithmetic mean was nearly three times higher (Table 24, columns E-F). Thus, PRR is a place of high concentrations of uranium when compared to the conterminous United States.

SOILS AND US EPA PRG COMPARISONS

In comparing US EPA PRGs (2012b) with results from the current study (Table 17), it is important to note the species of the element compared and that soil screening level PRGs are meant as initial clean-up goals at Superfund sites. In addition, PRGs are not applicable where natural background levels exceed US EPA screening levels, as is likely the case on and near PRR.

With that in mind, the average concentration levels of arsenic are well above the US EPA PRGs (2012b) for residential soils and ground water protection. The US EPA species is inorganic arsenic, not the total arsenic as in the current study. Concerning barium, average concentration levels were well below soil screening level PRGs for residential soils, and well above for one category of ground water protection, and well below for the other. Average concentrations for lead were well below soil screening level PRGs for residential soils and protection of ground water. Average concentrations for selenium concentrations were well below soil screening level PRGs for residential soils but well above for protection of ground water in both categories. For uranium, average concentrations were well below soil screening level PRGs for residential soils and below for protection of ground water in both categories.

BIOACCUMULATION OF SELENIUM

Comparing heavy metals levels in all wild rose plant tissues in Figure 17 with those of all associated soil samples in Figure 18, the study indicates that plants of interest at Sites 1-10 accumulate certain heavy metals from the soils in which they grow. The degree of uptake is not necessarily in direct proportion to the amount of heavy metals of interest in the soils, however. Bioaccumulation of selenium may occur in wild rose plant tissue at Sites 1, 3, 7, 8, 9 (Appendix G, Figs. G6-G8) where concentrations in the plant tissues sometimes exceeded the lowest concentration of selenium in the soils in which the plants grow (Figs. 17 and 18).

There is also potential selenium bioaccumulation in the fruits of wild roses at some of the 2012 sites on the White River (Fig.19). Although surface soil samples show low or undetectable levels of selenium concentration, rosehip concentrations were in excess of soil levels at Sites 11, 13, and 15. The rosehips may uptake selenium from higher concentration levels at greater soil depths or through delivery of selenium to the plants during periodic flooding along the White River. Only surface soil was sampled during the 2012 field season at Sites 11-15.

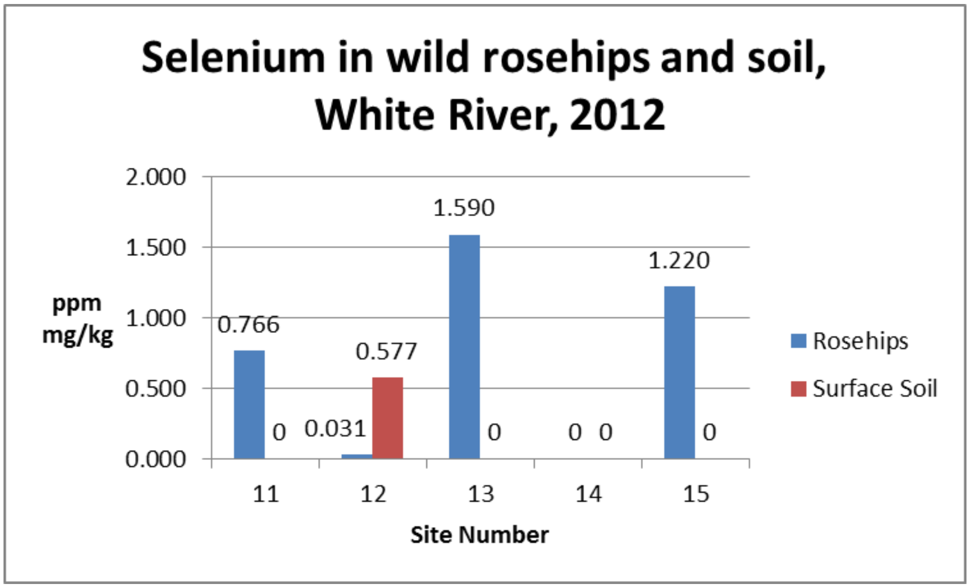


Figure 19. Paired columns comparing detected concentrations of selenium in rosehips and surface soil samples at Sites 11-15 (2012) indicated potential bioaccumulation of selenium in rosehips because of higher levels in some plant samples than the soils in which they grow.

Overall results for all plant tissue and soil samples in the study suggested selenium bioaccumulated in some fruits and other plant tissues. Of 104 total plant samples tested at Sites 1-15 (Sites 1-10 in 2011 and Sites 11-15 in 2012), identified as either fruits, leaves, or "other" (non-root, mostly flower parts and immature fruits), selenium concentrations were detected in 74 samples. Forty-one plant tissue samples (33 per cent), showed concentrations of selenium greater than at least one of the soil samples in which the plant grew. Sites involved included 1, 3, 4, 7, 8, 9, 11, 13, and 15 and at least one sample of all species of plants of interest in the study. A few samples showed higher concentrations of selenium than any of the soil samples at the site, including a plum fruit sample at Site 3, a buffaloberry leaf sample and a buffalo currant leaf sample at Site 4, and a buffalo currant "other" sample at Site 9 (Appendix I, Tables I-1, I-4; I-2 and I-3). Bioaccumulation was not analyzed for Brookings County, SD comparison sites, since no soil samples were collected.

CONCLUSIONS

This screening study identified areas where researchers should look more closely to see if health or toxicity risks exist. Generally, results indicate that modern day uses of traditionally edible fruits on PRR may increase the community's risk of exposure to certain heavy metals. However, more studies would be needed to assign definitive risk levels to specific ingestion quantities.

All ICP-OES sample results for this study did not differentiate between organic and inorganic forms of arsenic, barium, lead, or selenium, or specifically between "uranium soluble salts" and total uranium. Current standards and risk assessments from various regulations and guidelines cited in this study are based on specific forms of the elements of interest. For example, US CDC MRL (2012b) element forms are as follows for fruits: "arsenic, barium soluble salts, selenium, and uranium soluble salts." The WHO/FAO (2000 and 2012) standard for lead in fruit is specifically for "lead." USGS forms of elements reported by Shacklette and Boerngen (1984) for soils are listed as "arsenic, barium, lead, selenium, and uranium." With that in mind, significant findings are presented below.

1. In general, US CDC MRLs for reported annual oral intake doses of heavy metal containing fruits were not exceeded at the calculated mean heavy metal concentration dose. When based on the highest dose in the range for heavy metals concentrations in fruit samples, MRLs may have been exceeded for arsenic in

chokecherries and wild rosehips, and for uranium in wild plum and wild rosehips in 3 to 12.5 per cent (1 to 4 of 32 individuals interviewed) of those potentially ingesting the fruits on PRR, based on amounts reported by interviewees on nearby Rosebud Reservation.

2. Concentrations of lead in 8.5 per cent of fruit samples on and near PRR exceeded the WHO/FAO ML in the food category of small fruits. No samples of wild rosehips at comparison sites in Brookings County, SD, exceeded the WHO/FAO ML established at 0.20 ppm for small fruit. As noted in this study no MRL has been established for lead by the US CDC.

3. Selenium in fruits and other plant tissues was higher than the concentration detected in soil in which the plants grow at 9 of 15 sites in the PRR locale, indicating possible bioaccumulation in plants.

4. When plant tissue samples at sites along the White River were compared by year of collection (2011 or 2012), there were marked differences in uptake of certain heavy metals. One probable cause may have been in comparing a wet year with a drought year. Uptake was higher in the wet year as compared to the drought year for lead and uranium.

5. The database for the current study establishes preliminary baselines against which other research may be compared for small fruits on PRR and in Brookings County, SD, and for soils on PRR.

6. USGS baseline means and ranges for the conterminous United States for selenium and uranium in soils established by Shacklette and Boerngen (1984) were exceeded on PRR. The mean for selenium in soils on PRR was more than 18 times

higher, and the mean for uranium was more than 3 times higher than for the conterminous United States.

7. Lambert's (1998) conclusions that uranium levels are within US norms for the former PRR gunnery range are not sustained by the results in the current study, although there is no current evidence that heavy metals concentrations in soils or plants on PRR are anthropogenically caused.

8. There are a variety of worldwide standards for foods and soils that are neither uniformly updated nor accessible when making selections for comparisons in determining risk from exposure.

RECOMMENDED FUTURE RESEARCH

1. In order to determine heavy metals risks for residents of PRR and Rosebud Reservations, a study should include all possible routes of exposure: oral, inhalation, and dermal, using guidance available from US EPA and US CDC, as well as other sources. A total dietary study could provide a clearer view of true uptake potential.

2. Since small plot vegetable gardening is a current trend on PRR, researchers should consider a study of heavy metals in root vegetables such as potatoes; carrots; turnips; and Lakota *timpsila*, also commonly called "prairie turnip" or "prairie potato" in the Fabaceae family.

3. A controlled general study of high selenium soils and bioaccumulation in plants should be conducted.

4. A remote sensing study should be conducted to determine the use of known bio-indicator plants for identifying areas of most concern for high selenium soil bioaccumulation.

5. Since mercury is of key interest in environmental studies and was beyond the scope of the current study, a study of mercury concentrations in plants and soils should be conducted and could prove invaluable in managing resources on and near PRR.

6. Ground water studies on PRR may prove of great value for monitoring levels of heavy metals in general, and in monitoring potential sources of contamination. Such studies should include public education about the importance of using the already available rural water system in cases where well water may be preferred because of taste. Water has much more potential than wild fruits as a major, daily route of exposure to heavy metals if present.

7. Food standards are in the early stages scientific development and need to be expanded and unified in an increasingly complex worldwide food distribution system. There should be a clearinghouse website including all heavy-metals-standard-setting agencies in the world with the most current information available.

8. USGS baseline studies should be updated and densified to properly reflect the concentrations of selenium and uranium in PRR soils, since the concentrations are higher than any reported for the conterminous United States.

APPENDICES

APPENDIX A: INTERVIEWS FROM ROSEBUD RESERVATION, 2012

AN INTERVIEW WITH CORNELIA WHITE FEATHER (1)

In recent years I collect the following fruits on Rosebud Reservation to use as food: buffalo currant, chokecherry, wild grape, and plum. I mostly use them for dinners for the family, although we eat them raw when we go to pick them, too. For all of those fruits, we eat them raw or make them into *wojapi*, a type of pudding. We don't make jelly. Occasionally, I grind the chokecherries, pits and all, to prepare them for use. For the plums, the pits are always discarded.

My grandparents were traditional type people. Concerning these fruits, I do the things they taught me how to do when I was younger. We took a sheet and placed it under buffaloberry trees that had ripe fruit. Then we would shake the tree and the berries would fall.

When I first started collecting the fruits again, ten years ago, I took my nieces and nephews. I would tell them that we would collect these wild plants as each matured in the summer: turnips, currants, chokecherries, plums, and grapes. There is a Lakota name for the chokecherry time.

When I was out walking around, I found a good spot for wild turnips. As it turned out, the fruits I wanted were nearby, too. We don't tell people where I go. It is something children should do for exercise and fun and as a part of our traditions. The fun of going and getting it is the most important. It's the way I grew up. I wish my grandkids would do this. Next year we should go out. They should learn how. We need our plants for oxygen and everything. Hopefully the plants will still be around in the future. I want my grandchildren to pass this on. It is really important that we not lose that part of our culture.

Traditionally edible fruits are important at family dinners, wakes, and funerals. It would be unusual if they were missing at important events. If I went to a funeral, for example, and there were no traditional fruits there, I would wonder, “All right, who didn’t freeze the fruits this year?” (Laughs.) There are a lot who don’t pick the fruits, turnips, and other plants-- or prepare them anymore. It’s important to take the time to do it and make it fun.

My mom’s from here. I am enrolled at Eagle Butte (Cheyenne River Reservation), but I live on Rosebud Reservation. I think that Rosebud is named for the wild rose. I have a daughter named Chastity Rose.

AN INTERVIEW WITH CAROLE A. PROVENCIAL (2)

In recent years, I use the following traditionally edible fruits: chokecherry, wild grape, and wild plum. I eat them raw or make jelly, syrup, and *wojapi* (pudding). I also eat *wasna*, a spiritual food-- pounded together like sand. The dried ingredients include chokecherries, sweet corn, buffalo or other meat, and sugar. That is mixed together with any kind of fat, lard or shortening.

I use these fruits because I did it when I was young. I grew up that way. It’s a different taste than what you can buy in a store. It’s fun and I want to carry on the tradition and teach my children. It would matter if it didn’t get carried on; plus it’s family recreation. It gives us something to do as a family. It provides cultural identity. Now that I stand back and look at it, it is special. When I was young, it was just fun. I think it's important to save and teach these things so they don't disappear. My children need to pass them on. This is how we lived off the land. Should times get really hard, we can take these and eat them and live. The idea is that Mother Earth feeds us, rather than a supermarket. We have these resources here as part of the land. I think they should plant more of these just to save the bushes. We had a bad fire this summer on the reservation. Weather and forest fires, can burn out plants. By planting them in the yard, for example, you have them.

I was born in 1961 and I grew up in the 60s. Grandmother was in her 70s, and she raised me. She was traditional, although she didn't look that way. One of her traditional practices was getting berries and preparing them. And she had gardens. She canned chokecherry jelly and plum and buffaloberry. She also canned the juice to make things later on. She had a buffaloberry tree in her back yard. She would put a sheet under the tree and shake it. She had a big smooth grinding stone and another smooth stone held by hand. Uncles picked for her because she was old. She would pound the chokecherries with the stones and put them out to dry on screens or old curtains. They looked like hamburger patties as they dried in the sun. She hung the dried patties in cloth bags in the porch for the winter. Then they were handy so she could use them throughout the winter. She would boil them to rehydrate them. She would make *wojapi* (pudding), and jelly with the ground pits included. She also used the dried berries to make *wasna*, but back then it was just food. The berries were pounded down and ground. Sometimes we would just eat that. Her *wasna* included ground up berries; meat, (sometimes buffalo) dried or roasted; sweet corn; lard; or fat.

In my late thirties, I started doing this, myself. We make jellies with it. I store and preserve the chokecherries and plums by cleaning, pouring into gallon Ziploc bags, and freezing. We give them away in those bags. When someone dies, we give to them to make *wojapi* (pudding) or *wasna*. Both might be served at a wake or a funeral. I give my jellies and homemade bread as gifts at Christmastime.

Mainly, we pick and prepare the fruits every August. We do it as a family, with helpers from about age three and older. When it comes to wild berries, we take what we can find. Turnips are important too. It gives us something fun to do. One fall we all went turnip hunting for the weekend. We have our private spots that we keep location to ourselves for our little group.

I just know that when I was growing up it was lot of fun and I liked to help out. I didn't even realize I was learning this stuff, until one day when I decided to do it again. I don't have a grinding stone anymore. We use metal grinders when we need to. We pick and store. It reminds me of my relatives, including my grandma, Ada Whipple.

I know people named Rose. It's a bit of an old fashioned name today. I don't think there are more people here with that name because of the name of the Rosebud Reservation. People associate the name Rose with the Rosebud Reservation because it has many wild pink roses. It's just filled with them. I am enrolled here.

AN INTERVIEW WITH BYRON PROVENCIAL (3)

Lately, I collect and eat these traditionally edible fruits on the Rosebud: buffalo currant, chokecherry, and wild plum. I have always used traditionally edible fruits. My mother picked them. Our grandparents used them. It was just what we were told-- to keep it up. They showed us different ways of doing things and how to make different things with berries. The taste matters, but so does collecting and preparing the berries as a family. They used to use corn for soups and stews, and that was good. I have had chokecherry jelly both ways, with and without the pits ground into it. I like it without. With *wojapi* (pudding) it is good both ways. With the pits ground up in it, it feels gritty going down, but it has more taste that way.

I would miss it if the tradition were lost. I have eaten it since I was a small child. It would be strange to go to a funeral without seeing traditionally edible fruit dishes served. At a ceremony, I would expect to see it. Some examples would be the Sundance, powwows, and traditional weddings. *Wasna* is the mourning food for the Native American Peyote Church. Sometimes the berries are sold at booths at certain special events.

I have eaten buffalo currants in cake. In addition, I have eaten chokecherries in jelly, syrup, and as a seedless, sweetened paste that covered wild game meat as it roasted in the oven. All I could taste was the meat and berry---the sweetness was not there. It was used on deer and elk. My aunt made chokecherry wine and gave it to friends at Christmas and Thanksgiving. That was within 18 to 20 years. Mom made ground and dried patties with chokecherries. She would rehydrate sometimes and make things. She mixed chokecherries with plums and made *wojapi* (pudding) or jelly. She also made straight chokecherry or plum jelly. She used Sure-Jell brand thickener. She sealed the jelly jars with wax. They canned the juice to use later. If she needed to strain the crushed fruits, she used cheesecloth. The chokecherries, in particular, would cause a permanent stain in the cloth.

We had plum and chokecherry bushes all over by the river. We would get buckets or pillowcases and pick the berries. She would clean the berries and separate them into each bucket and bag them up to freeze them. She would start boiling it and making jelly and jam. I remember that was about 1977 or 1978.

I have felt an obligation to keep it going so the future children can learn what we had. We want them to do the same thing we did. They need to know about *wasna* for ceremonial use. Of course, they could make it from chokecherries and plums. Ours was almost like *wojapi* (pudding), but not exactly, more like fruit leather. She would sugar that up and put it in a bowl. She would add raisins and mix it up. It was a really thick, a sweet side dish. Although it was dehydrated, it would still pull apart. She made that when I was eight or nine years old. I was born in 1969 and am an enrolled Rosebud member. It would be nice if the information were saved so that people in the future know what we did, what we used it for, and how it was prepared. It will help them follow and do the same things we did.

There are quite a few people with middle or first names of Rose on the reservation. You would not be likely to select it today because it's a little old fashioned. When I was growing up it was used more.

AN INTERVIEW WITH MELVIN GUERUE (4)

Currently, I eat the following fruits collected on Rosebud Reservation: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips. The chokecherry can be used as medicine for poison ivy problems. For the buffaloberries, I pick one and taste it to see if they are good. If the berry pops, it is good. If they are, I pick some and take them to use as a dessert when I have soup or fry bread. I don't go to extremes when eating them. I don't eat more than seven berries at a time. I don't eat all that I pick in one day, either. That would upset my stomach.

It is best to pick berries before sunrise. If I go to pick berries in the evening and a frost comes up and kills them, they are no good. If I try to get more, there's a frost that will kill them. It is the same way with buffalo currants.

When it comes to chokecherries, I usually say that my great-grandma and grandma showed me how to use them. I watched them. They don't use a hammer or grinding stones. They grind the berries with solid bricks. They made a big patty to dry. The crushed chokecherry patties were spread on canvas to dry and then hung on a clothesline for a total of about three days. She stored them, dried. She used them to make *wojapi* (pudding). Even plums and other wild berries could be used. She added corn starch or a little flour, and sugar. There is no meat or grease in *wojapi*, because it's a sweet pudding. Each flavor is separate. You don't mix chokecherries and buffaloberries, for example. All of the fruits involved include the pits in the recipes, with the exception of plums. The large plum pit is always removed and not part of the food. They also used powdered dry milk, when available, in their recipes.

They used rosehips and their seeds for flavor in rose *wojapi* (pudding). For rose tea, they would go into the valley and smell the leaves to be sure they had the right odor. They used early leaves but no rose petals or rosehips for the beverage.

My uncle would tell us how to collect plums. We put a sheet or canvas or table cloth under the plum trees. He would shake the tree and the plums would fall to the ground where we could collect them. We had to be careful of poison ivy when picking berries. We put on boots and gloves. We would fill large buckets with fruit.

The chokecherries make a good medicine for someone who has caught poison ivy. You can steam it up and use it like lotion. You avoid scratching. Let it go. It will dry up. The other one was plum. My cousin was scratching away, and dad said poison ivy got on him. He went and got flour and browned it and made a powder to apply for poison ivy.

Wasna can be made with chokecherries. You dry the chokecherries and crush them. Then you mix them with corn meal, powdered milk, and a little bit of lard. Set it aside for an hour. It is ready to eat when it is dry and grainy like crushed up cereal.

The buffaloberry is a tonic because you drink it straight. Tonic is important to us to help avoid infection or illness or abdominal upset. It must be used in moderation, though, because it can cause stomach upset if not kept within limits. It is best to limit sugar in these traditional recipes to limit diabetes problems.

My grandma told us to do this and that. I can still remember what she told me. I am 60. Grandma's name was Mabel Hollow the Hawk. The fruits grew just like money on trees. She was elderly then and did the cooking. I would help her and watch her and catch on. So, now if I do cooking I know how to do it. She didn't go by measurement. She knew what to do.

If I don't have anything to do, I walk, and I know where the fruits are. I take friends along. I let them go first in case there are snakes! (Laughs.) I pick one relative of mine and send them in there. I tell him not to tell everybody about this private place. I tell him not to bring anybody else. In our household, I use all of the fruit that I collect.

I make God's Eyes wall decorations. The frames are chokecherry twigs. I take a potato knife and scrape the outside down to bare wood for the circular frame. I add feathers and I have them in the house. I don't sell them. I keep them where there are no kids around. When a relative dies, I give them away at the funeral. I make them from six to 18 inches, in matching colors.

My uncle, Moses Big Crow, was an instructor for St. Francis Indian School, the boarding school, and he was trying to get us to dance, but we weren't interested. But he showed us how to do art and beadwork projects. I attended the boarding school there from 1965 to 1967 and lived in a dorm. He also talked about how to use traditionally edible fruits. I told other students ahead of time because I knew from my grandma. My uncle talked to us in Lakota.

When summertime comes, we pick traditional fruits off the tree. It's the Indian way to pick them up. It's a traditional way. It's money saving. The children catch on. It's important to continue as a tradition. When winter comes, we get more store bought foods.

AN INTERVIEW WITH ANONYMOUS (5)

In recent years, I have used the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

My mother used to make traditional foods from the fruits, and I helped. Concerning buffaloberries, we made them into jelly and put it on bread. We ate a lot of them raw, too. Mom would want the berries to can them, but we would pick and eat. She would say, "There is not enough for winter. Those are the hard times." We also picked and ate ripe buffalo currants. Mom froze them, and we have them for snacks. We didn't make jelly. She juiced all of the berries and used them in place of Kool-Aid. She used another wild berry, too. It looked like a raspberry, and she would add it to muffins. There are purple and red ones, but I don't know the name. She would make juices out of those, too.

To process chokecherries, Mom and I put them through a metal meat grinder. Then we put them into patties and put them on a screen to dry outside for about three days. In the wintertime, we made *wojapi* (pudding) by rehydrating the dried chokecherries with boiling water. We used the dried chokecherries for *wasna,* too. We hardly had sugar, so we used corn syrup from commodities (when we needed to), and a flour and water mixture to thicken *wojapi*. Ingredients for *wasna* don't include grease--just sugar and ground raw berries. She bakes it. When it's done, it's kind of wet. She pours the fruit's juice over the mixture when it comes out of the oven. It's served in a bowl and is the consistency of raw hamburger. You dip it out of the bowl with a spoon. Mom used to crush the berries with rocks (mortar and pestle), until she met my step-dad. Now she uses a metal meat grinder and prefers that.

Concerning wild grapes, we just pick them and eat them fresh. Mom used them for juices. She canned or made them into jelly, too. She strained the seeds out and used just the pulp and skin. She used corn syrup. It looked a bit like pancake syrup.

Mom canned plums. She would get five gallon buckets of the fruit. She pitted half of them. She froze them, too. I think she used those for medicine in the wintertime. She puts another ingredient in with them. I don't know what that was. She made a medicine that we had to take in the wintertime. She used plums for *wojapi* (pudding), too.

When it comes to rosehips, formerly, we picked the little miniature “apples” and ate them. We spit out the seeds. Mom and those folks used rosehips tea for ceremonies. I think she used leaves for the tea. Today, I don’t use tea at all. We don’t use rosehips today. Mostly it is just buffaloberry, buffalo currant, chokecherry, and plum. We collect turnips, too, starting in June.

Then Mom used to make another tonic for everyone to keep them healthy. It included chokecherries or plums, and maybe cod liver oil, or maybe something else. She made us drink that as a tonic. It was really gross. When we saw her making it, we all took off running. I don’t give that to the kids today. I say, “You guys have what you need when you get sick. We had it hard.” I also don’t like sage juice for stomach aches. That stuff is bad. My mom gave some to my kids when she was still alive. They were staying with her. After six months, the kids said they didn’t want to stay with grandma anymore. They said, “Grandma gave us a tonic. She boiled it and said it was tea. When we ate we had to drink it.” She told me that she gave it to them to cure constipation and not at every meal. Now my daughter says, “When my boys get stomachaches, I am going to give them sage water!” She doesn’t mean it, of course.

I remember that back in the day, my grandma made chokecherry patties and they were drying. My uncle was gone a lot on farm places. He came back with his co-worker. My grandma had patties drying outside, and her corn was drying, too. In addition, meat was on the line drying out. My uncle grabbed one of the chokecherry patties. They cut the bread and put the patty in it. They ate it, because they thought it was hamburger. Grandma got upset. She took her chokecherry patties inside when they weren’t really dry. They rotted because they were too moist—so she lost her chokecherries that year to mold. My uncle had to stay at the ranch, and she had him pay for those chokecherries they lost.

One of my ancestors, Albert Black Mountain Sheep, was a medicine man, and he stayed away from the public. He lived in a car body away from other people. He walked the hills a lot. Because of his spirituality, he remained away from others unless they came to get his help. He knew they were coming, even though there was no way to communicate with them. My mother tells me stories about him. She picked plants (not fruits) for him for medicine. Mother said that Bessie, Albert's wife, taught her to work with chokecherries and plums. They dried everything because they had no way to freeze products. Albert helped people look for someone who had lost a son. So he was gone for days helping them. He needed the plants for a ceremony that he would use to help them. He told them their son was in a basement of a house in California. They should go get him. He said he would put up red flags for them to follow to get him. They got him and returned him to his reservation (probably Pine Ridge) and did a thank you ceremony.

My girls participate in the Sundance. I was brought up in Lakota religion, so I know all about it. I chose not to go and Sundance. I sweat and go to ceremonies. I know how hard it is, so I don't Sundance. There are foods that are served there that have to do with the traditionally edible fruits. Chokecherry juice and buffaloberry juice are for Sundancers if they are dehydrating, and for ceremonial reasons.

AN INTERVIEW WITH MICHAEL WHITE BUFFALO CHIEF (6)

In recent years, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

Concerning buffaloberry, the berries are boiled, and sugar and cornstarch are added to make a pudding, *wojapi*. When it comes to buffaloberry, we have *wasna* with corn. It's only supposed to be for religious ceremonies because spirits are more attached to the corn. The buffaloberries are also made into jam that is thickened with Sure-Jell.

When it comes to beverages made with buffaloberry, buffalo currant, chokecherry, wild plum, or wild rose plant parts, we add sugar to some. We limit sugar now because some have diabetes. Sometimes it is just the fruit boiled in water and strained and put into a container. In native religion, we can it and put it in containers and make beverages for Sundancers to prevent dehydration. We take a dancer into a sweat lodge and feed this to him to help keep his strength up. When done with four days of the Sundance ceremony, we give the dancers a drink of buffaloberry juice before they go into a sweat lodge. The participant can have Gatorade or coffee, pop, or Kool-Aid and the like—but not water. They cannot even touch water because it might cause the Thunder Gods to come down, and that usually brings storms and rain and lightning in four directions. Or the lightning could hit the Sundance tree, too. If lightening hits it, the Sundance is over. Their family members bring that juice to them. The dancers can't touch water for eight days while in the ceremony. They pray with the water. I can offer them water to drink because I am "a backwards" or *heyoka*—so I can do that. That's my role.

Grandmother showed me how to do the stuff. She explained how these things will be used with the native religion. I know how to can for winter, but in the old days, they had to dry fruits because we didn't have freezers.

The *wasna* that we give them in the Sundance is the corn type. When they come back from their vision quests, we have a container of dry meat, bacon or lard, plus chokecherries, and if they are lucky, they have plum juice when they are done eating.

For roses, we just use the leaves for tea. We can't use the little rosehips because only the elderly can deal with that. Grandmother said not to touch the rosehips until you are an elder.

Grandma, Hattie Black Mountain Sheep, used Iktomi verses to prepare the food and get ready for winter or religious ceremonies. She said what to do and what not to do. I like doing all that instead of looking for things on shelves. If I go in the wilderness, I can pick them, but I have to have an elder to deal with rosehips, but I can deal with the rose leaves. We took tobacco out and threw it down as an offering when we picked parts of the rose plant. If I needed to get rosehips, I broke the branch off and took it to her with the rosehips attached so that she could take them off.

We pick chokecherries and put them in bags in the refrigerator. We don't freeze any fruits. It tastes better dry.

I was born in 1962. I am a member of Rosebud. My wife is Winnebago Indian, and they tend to do things differently than the Sioux. I have been trying to learn their ways from my wife, but it is hard to pick it up, as to how they do theirs. Her mother was showing us how they prepare food. I told her we do it differently. I explained how we do canning and all that stuff. We do it my way at our house.

When deer season comes, I try to get some meat from a friend, and I slice it and dry it for the winter. We can grab a piece of that dried meat with some dried sweet corn, sliced salt pork, and water. In addition, I make a six foot braid of turnips that lasts all winter. We add it to soup—even at Sundance. A bowl of *wojapi* (pudding) and fry bread often goes along with it. The elders really like that around here.

My grandpa, William Points At Him, told me quite a few Iktomi (Spider/Trickster) stories. He used that to kind of teach us kids how to behave ourselves. One story he told involves chokecherries and wild roses. Iktomi and coyote were walking and came upon a bush with chokecherries. Iktomi was eating them. The chokecherry plant turned around and said, "If you eat me, you will itch." He ate more anyway and took some in a container. He was scratching, and he found a rosebush with thorns and started scratching himself with it. The more he scratched, the more he saw wild rice falling out. The coyote took the rice and the chokecherries. They came to a pond with some ducks. Iktomi went over there to get them. He packed wood and went down there. They saw him coming. The ducks said, "Come and sing for us." Iktomi said, "No, I am in a hurry." The ducks begged for him to come back. He told the ducks, "You have to stand in a circle, and I will sing a song. You need to close your eyes. I am singing a sacred song." So they did. As they came closer, he hit the ducks on the head and threw them in a bag. Some took off in flight. One turned around and looked at Iktomi. He told the ducks, "You turned and looked at me, so you will have red eyes now, forever." So they have red eyes. So Iktomi and coyote sat down and ate berries and ducks. So, they had a full belly and they lay down under the tree and slept.

My wife's Winnebago name is Picks Berries. Mine is Eagle Shield. My first Indian name as a little child was "Women Comes Looking For Him." I was told that when I was born, all the women came over to see me. So grandma gave me that name. My grandpa said, "Now women cannot come looking for you—you are married." So, I had to go to the sweat ceremony to get a new Indian name. Grandpa shook my hand and said, “Here is your new name, Eagle Shield.” I asked, “What happened to my old name. He said “We took it away because you are now married.”

AN INTERVIEW WITH ANONYMOUS (7)

In recent years, when rainfall was normal, I collected and ate the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

I was brought up with no electricity, no running water, and an outhouse. While the men were sweat lodging, I helped grandma get the meal ready for them, and it would include some kind of traditionally edible fruit, such as chokecherry jelly and *wasna*.

With buffaloberries, I make *wojapi* (pudding). My grandmas used that for jelly, and I still do, along with jam. We spread it on bread. When we picked buffaloberries with Grandma, we held sheets or blankets under the trees, and she hit it with her cane to make the berries fall. We avoided sharp thorns. I wondered why my sister and I had to hold this blanket. Of course, we could catch more berries that way. She would direct us so we didn’t miss any.

The buffalo currants we just eat fresh. My Grandma made jelly, but I don’t because I think plum and chokecherry are better. Concerning chokecherries, we eat them raw with salt, make jelly (with pits), or grind them with a metal grinder and make patties and dry them out. We rehydrate the berries later and make other things.

My Grandma canned plums and chokecherry juice and made jellies later with it. For ceremonies involving healing or prayers for the sick, we use chokecherry juice with sugar. For a funeral you would have wet *wasna*. It can be made in different ways, but it is always baked and then drizzled with chokecherry juice. It is served in a bowl and is the texture of raw hamburger.

With wild grapes, Grandma made jelly and jam and juice. I make that jelly and juice also, including frozen popsicles with added sugar. For jam and jelly, one requires ground berries with pits and the other calls for cheesecloth to strain the juice. I make baking powder bread. The ingredients are flour, milk, baking powder, and a little sugar. I don't knead it—just pat it instead. It is formed into patties the size of my hand, and then deep fried. We put jelly on it. The kids make holes in bread for the jelly to seep in.

Concerning wild plums, we eat them raw with salt, or I make jam and jelly. I also make *wasna* for religious or healing ceremonies or for funerals. In addition, I make *wojapi* pudding to eat or use for ceremonies or for honoring. Sometimes for powwow we have it for dessert. We picked plums last week, but they are not as big as usual. They were very small. I am going to make jam with them. I have many children, but the five girls went along. I will use sugar, Sure-Jell, and plums. For wojapi (pudding), I use flour to thicken it. Sometimes when making roast of meat, I put in a cup of dried plums. That will make the gravy lumpy—so I strain the gravy. Sometimes my daughter and I would pick berries on horses.

We don't use rosehips, the little apples on rose plants. We only collect this year's tender rose leaves for making tea. We steep the leaves in hot water.

One of my ancestors, Francis Quick Bear, Sr. used chokecherry twigs for ceremonies. He used them for vision quest. In that case, he would have four stakes about five feet long. They were made of chokecherry branches stripped of their leaves. He would put them around the participant and attach cotton cloth strips of the four colors: red, yellow, white, and black (or blue or green). That is still practiced today.

Concerning the Sundance, first they have a sweat to get prepared. Then they go at 5:00 a.m. to their vision quest site, where they stay for four days to fast and pray. A traditional fruit beverage is given here if they are getting dehydrated. Then they come back to the Sundance tree and get prayed over by a medicine man. Then they are pierced. They go back to camp and wait for all the dancers to get done. They have a last sweat. Then they eat traditional foods at the end, including traditional fruit dishes.

I am enrolled at Rosebud as a full-blood, am middle-aged, and going to school at Sinte Gleska.

AN INTERVIEW WITH SIDNEY L. REDDEST, JR. (8)

In recent years when there is normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

I collect buffaloberries on horseback and eat the fruit raw. They are hard to pick. So I don't collect them by the bucket. Concerning buffalo currants, I just eat them raw as I find them by going from meadow to meadow. I pick more chokecherries in larger amounts and grind them for *wojapi* (pudding) and *wasna*. I pick them in ice cream buckets and pour those into five gallon buckets. If it is a hot day, adults do the picking because it is not a good time to take kids along. It can be a family event if the weather is nice. Sometimes when I am on horseback, I simply see some berries and stop and pick them. There have been times when I have collected them in my hat, for example.

Concerning wild grapes, I hardly ever see them. I would pick them if I found some and they were still good and juicy. When Grandma Sara High Pipe was around, we would go as a group to get plums. Now we go by ourselves and get what we need. We don't pick or use rosehips or rose leaves.

Buffaloberries or buffalo currents make good *wojapi* (pudding). It is cooked slowly, and for sweetener you can also use honey. Back with grandma, she made jelly or jam with it. We don't, now. We don't can or jar them. Since Grandma's time, we don't make it as much.

With chokecherries, we make *wojapi* (pudding) and jam. The taste of chokecherries is between bitter and sweet. We grind the chokecherry pits into it. Nowadays, to keep them until needed, we use a metal meat grinder to crush the chokecherries. Then we put them in freezer bags with juices as one big lump. In contrast, Grandma ground the berries on a large flat rock with a fist-shaped rock held by hand. Grandma used to get up early and take six, five gallon buckets and get all the fruits they could find. They went to various places to collect. Sometimes fruit is only good to collect every other year. Now, working with chokecherries brings back memories of picking them a long time ago.

After we collect plums, we just pit and freeze them. At that point, they are ready to use. For plum *wojapi* (pudding), we add corn syrup and corn starch.

I like to go on horseback to pick berries with eight or nine cousins. We like to go where the water hole is. Even the windmill would work. Those are the best times I had with my cousins. If we were gone for so long that we missed a big meal, Grandma Sara High Pipe would save it for the next meal. She always had traditionally edible fruits. We would go in her house, and it would look like there was nothing much there, but she could make a good meal. She could make fresh bread, too. She lived on the west end of the county. We all grew up there. Lots of times we had horses that got away, so we would catch one or two and chase after the others. We would come across these fruits in the meadows and draws. Through hunting and so on, we know where to find the best places to pick berries. We also dug turnips.

Now, every time we go out to pick berries is a good time. I have kids, too. One is in college now and the youngest is one year old. With the younger ones, I did more turnip digging.

The berries and turnips are often served at ceremonies, dinners, funerals, wakes, and traditional events. The fruits could be for sale, here at the Rosebud Fair. Sometimes they offer chokecherries, plums, or turnips. A braid of turnips might cost twenty-five dollars. Five gallons of chokecherries would be about twenty-five dollars. The plants are not cultivated. They grow wild. Water from the water towers is not best for irrigating these plants. Maybe it is the chlorine. Chokecherries need fresh water to do well. They grow well near natural water sources or in draws that catch the snow.

AN INTERVIEW WITH LESTON BREWER (9)

I am not an enrolled member of Rosebud Reservation, but culturally I am a part of the locale because I have been around here all of my life. I live just over the state line in Nebraska. In a recent, normal year with average rainfall, I collect and eat buffaloberry, chokecherry, wild grape, and wild plum. Concerning all those fruits, I eat them made into jellies. They are made by cooking and straining the berries, sweetened with sugar, and thickened with Sure-Jell. I also like wild grape juice.

As kids we'd have berry fights, just for fun. Of course, we collected them to eat and make jelly. Basically, we did it with mom and grandma and the kids. I just kept it up as I got older. Today, when I am out working cattle, I might see berries growing and just eat some of them raw.

I was diagnosed with Hodgkins, and it hadn't turned to melanoma yet. So, I started reading on the subject. I read anything I could get my hands on that wasn't American Medical Association approved. I knew some of the names and some uses of traditional plants from native lore that were talked about in the range programs in Future Farmers of America meetings. So, I went out and got the herbs and made tinctures. I took just a little—not too much. In a month or so, I was out of pain. The plant identifiers had passed down the native lore. None of these plants are fruits. The medicinal plants include purple prairie coneflower (echinacea), mullein tea, leadplant, and others. I think there is something to be learned from native medicinal practices that are ignored by modern medicine and the pharmaceutical industry.

AN INTERVIEW WITH KEITH MURRAY (10)

In a recent year with normal rainfall, I collect and eat buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum. I like to eat all of those raw.

For chokecherries, I eat *wojapi* (pudding), but not the jelly. Concerning plums, I eat some jelly, as well as the dry *wasna* made with meat, corn, berries, sugar, and lard.

Women make the prepared foods. They grind chokecherries (including pits) in a metal meat grinder and dry them, storing them in cloth sacks to stay dry. They don't can them.

I was nine when I picked chokecherries with my grandma, Sarah High Pipe, and my uncle, Omer High Pipe. We climbed the trees and got the ones at the top. We often got five gallons. I watched her get them ready to dry in patties. Her *wojapi* (pudding) was the best dish she made from chokecherries. She also made it with plums. I miss going out to get the fruits as a group. It brings back memories of the old days when I eat it and the taste is just right. Everyone makes it differently. It's becoming a lost art. I personally don't know anyone who makes it. There are still places where people serve *wojapi* (pudding) and fry bread with jelly.

I will go out of my way to pick wild fruits if I see them. Plums are my favorite because they are the sweetest. Normally people don't grow them in their yards. It's fun to pick them in the wild. Of all of these berries, raw chokecherries are the most likely to be sold here today at the Rosebud Fair.

AN INTERVIEW WITH NICOL BUROW (11)

In a normal, non-drought year, I eat and pick chokecherries and wild plums. Concerning chokecherries, I eat them raw or dried as a snack. Sometimes I mix them with unsalted nuts. I eat plum *wojapi* (pudding) sometimes. I have only made it once, but I eat it at other events. It is made with pitted boiled plums, sugar, water, and cornstarch. Personally, I don't can, freeze, or dry the berries. I use them fresh when I have them.

I was in about second grade when I started picking the berries with friends. I am now 24. Every once in a while we pick them, but it's not as common as in earlier generations. I eat those foods at funerals and ceremonies. I expect to see them there.

Sometimes we take our kids on outings so they will know what to look for and what to pick when they get older. We only collect turnips, chokecherries, and plums. I have never been taught how to can the juice, freeze the berries, or dry them. It doesn't bother me not to know how. It's not high on my priority list. We don't have a specific place or have outings as a regular part of my family. I don't remember any stories about traditionally edible fruits. My family was not all that traditional. Grandma didn't make chokecherry jelly or plum jelly. So, we ate the berries as snacks or if someone else served them, but that was about it.

AN INTERVIEW WITH MARIA IYOTTE (12)

In an average recent year, I collect and eat buffalo currant, chokecherry, and wild plum. I am not an enrolled member of Rosebud Reservation, but I live here. I know that I am Lakota, but I don't know which tribe. So, I am not enrolled because I cannot get enrolled since I don't have the papers to prove it. Culturally, I am Lakota with my heart and soul.

With the buffalo currants, chokecherries, and plums, I make juice, jam, jelly, syrup, and *wojapi* (pudding). The other ingredients in *wojapi* are water, sugar, corn starch, and flour. I use Sure-Jell to thicken the jam and jelly. I have never made *wasna* yet.

Here is how I prepare buffalo currants. Remove the stems and boil the berries in water for a long time. Strain the mixture in a metal sieve. Add sugar. For juice, just dilute it with water.

Concerning chokecherries, for syrup, cook the berries with pits in water for a long time. Strain through a metal colander. For juice or syrup, cook the whole chokecherries with a little water for a real long time; strain through a colander; and add sugar to the juice. For jelly, add Sure-Jell to thicken it. If it remains too thin, it is syrup! With the leftover pulp, put it in the blender and make *wojapi* (pudding) by cooking that pulp with sugar, water, and corn starch or flour to thicken it. I put it in jars in a water bath to can it. I sell it door to door.

For wild plum syrup, I use 1200 grams of the fruit with 1 kilogram of sugar and a little lemon juice. The process for syrup is to boil the fruit with a little water, cool, remove the pits, and add sugar to thicken it. To make jam, boil the plums, cool, remove the pits, puree it in the blender and boil it again and add Sure-Jell. To make *wojapi* (pudding), do the same, but also add flour or cornstarch.

I was one of the Lakota “lost ones.” I was adopted as a baby in l962. My adopted mother is from Prague, Czechoslovakia. We moved to Vienna, Austria with my adopted father in 1967. I grew up in Austria. I always felt different, and I didn’t know why. I was a tomboy. We played cowboys and Indians. Kids picked on me in school. I had to learn to fight. I took up Judo. I got my self-confidence. I was fifteen when my adopted mother told me I was adopted and Lakota. My response was like falling into a black hole. It was devastating. My world crashed around me. I tried to fit in, but I could not. It was impossible. If you are Lakota you are Lakota.

I met my Lakota husband in Austria in 1999 when he was in a rock band. I was there to support Native Americans and bring them to our group if they had problems. We married in 2000. First we lived on Pine Ridge, now on Rosebud. Together we have one young son—and six other children from previous marriages. Both my husband and our son are enrolled at Rosebud. I am working on obtaining citizenship. We have 20 grandchildren.

One time I found berries on the reservation, and I just wanted to make plum jam. My husband liked it so much, I thought of selling it. I go from door to door and make products from the fruits listed above. I plan to expand to other traditional fruits, too. I make jam, jelly, juice, syrup, *wojapi* (pudding) and homemade bread for jelly. I am selling the plum syrup at the Rosebud Fair. I would be interested in expanding the business in a way that would create jobs and product branding on the reservation.

AN INTERVIEW WITH LEANA LONG PUMPKIN (13)

In a recent year with normal rainfall, I pick and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

I make buffaloberry jam, using the whole berries with Sure-Jell and sugar. I use a blender to puree the fruit, although I tried the rock grinding, and that’s hard to do, but it works. I learned that from a friend. I can the final product with sealed lids.

I eat raw buffalo currants, or sometimes a friend gives me jam and makes *wasna*. I don’t dry the berries, and sometimes I make *wasna*.

With chokecherries I make the *wasna* and juice recipe. It's the same basic recipe when using buffalo currants. We just drink juice, but we don't sweeten it. I save some of the chokecherries by freezing them in case I want them for funerals or other ceremonies. They can be used for *wasna*. That would include chokecherries that are stone ground and dried (or if frozen, they are pureed in the blender). They are mixed with dried buffalo or beef meat. For buffalo, the dish just includes chokecherries and dried buffalo meat with a little bit of buffalo fat. It makes a dry wasna. There is also sweet corn meal *wasna* if someone gives me dried corn. In that dish, it includes dried meat, corn, raisins, kidney fat (buffalo or beef), sugar, and no other fruit. We also have *wojapi* (pudding) made from chokecherries.

Wild grapes are eaten raw or frozen. The frozen ones I want to dry with a dehydrator, but I don't have one. I want to try grapes in *wasna*.

We eat raw wild plums or make *wojapi* (pudding). We don't make juice or jelly from grapes. For the *wojapi*, we boil plums in a little water, take the pits out, add sugar, boil, and add flour to thicken the mixture. We don't can it because it is used right away as dessert.

We make tea with dried rose leaves in spring. We steep the leaves in boiling water. I have picked red rosehips and made a tonic with the whole hip. I drank it because I didn't want to get the flu or a cold. It is a tonic.

I took a Lakota botany class at Sinte Gleska school, and we talked about the different plants and harvesting seasons. I remembered the happiest times of my life in first grade. My aunt would take all of her equipment, and we would go pick berries. We took our buckets and had long sleeves and long pants. Our shoes had to be boots. I never saw grandma or my aunt in those types of clothes, otherwise. They wore pants, but they wore dresses and aprons over that. They borrowed men's shirts. It was poison ivy protection, I guess. We collected on the Six Mile Road, near Rosebud and farther up the road from Rosebud Dam. We got up early and picked chokecherries. It was cool. The afternoon was so hot. My teeth were temporarily stained brown from eating chokecherries. We had buckets, water, chairs, and flour sack towels. We collected berries in flour sacks.

I remember all of that. So, I started taking my grandkids to pick berries about five or six years ago. My oldest are eleven and nine now. I'm 53. I have fifteen grandchildren. My grandma's name is Frances Sires, and my aunt's name is Angeline Kills In Sight (married name Long Pumpkin). Those two influenced me the most when it comes to harvesting. I want to pass it on because it makes me happy. At the time it was a serious thing because they were preparing for the winter. You had to do it the way they told you. They would punish you by making you go sit in the car for goofing off. So, I began harvesting a lot. I start with turnips and go on through to roses. The weather influences success a lot. I want to make the tool to dig the turnips. It's like an awl, but it is like a shortened crowbar.

I tell my kids why I make *wasna*. The cornmeal we use in ceremonies or to feed our living elderly. It's a spirit food. Now I am learning more about all the whys and wherefores concerning how our ancestors did these things. We never questioned it; we just did it. Now I can explain it better. I would like to teach it in school. Grandkids ask why. They have a hundred questions. I am trying to learn the answers and how to teach the reasons for the young today who question our way of life.

It would seem very serious at a feed if the *wojapi* (pudding) were not just right. I would think, "No one gathered it." One year it was all just canned food. I thought, "What's going on? Are we teaching our children to harvest?"

It helps us to take our culture and keep it, in the same way that language and ceremonies do. I would like to bring back a woman's society where we'd teach young girls to be women. They would go through a rite of passage. "If we don't harvest, our plants will go away." A medicine man told me that.

AN INTERVIEW WITH CAROLYN BLACK ELK (14)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

With buffaloberries, I make jelly, syrup, and *wojapi* (pudding). I preserve or freeze a few gallons for special events. I donate some to other people. I prepare the jelly with Sure-Jell or pectin, and I can them but don't water process them because they are used so quickly. I recycle the jelly jars. They reseal one more time—but I check them. They are meant just for use right away, not for long term storage. I use the colander to get rid of seeds and some of the skin. My husband's uncle made buffaloberry ketchup. We never got the recipe, and he died before we could.

We eat most of the buffalo currants right away as raw fruit. I also make jam or jelly. I cook the berries and thicken them and serve them to friends. I use the same process to make jelly as described for buffaloberries, but I use smaller jars, usually about a half to one cup. They are not preserved, so they are used right away.

Concerning chokecherries, I eat them raw with no sugar when they are fresh. I make some *wojapi* (pudding), or I freeze them. I can the juice, and it is used quickly. With the juice, I make *wojapi*, jelly, and jam. The best jelly is produced by grinding chokecherries and then extracting the juice with a colander. There is more flavor that way from the pits. Sometimes I need some canned juice for ceremonies. I do the same with the frozen chokecherries. When I make *wojapi* (pudding), I grind the cherries and add sugar and flour, or cornstarch. I serve it in a bowl. The kind of chokecherry *wasna* I make is moist rather than dry. The following are the ingredients: dried meat, mostly deer (or beef), kidney fat (sometimes), juicy chokecherries including the pits that are ground in a metal meat grinder (not fine). I use a metal hammer to break up the dried meat to the consistency of sand. I also add kidney fat. If the taste if not sweet enough, I add a little sugar. I eat fresh wild grapes, or make them into grape jelly, or freeze the berries to eat later. Mostly, I make juice after eating some fresh wild grapes.

We pick a lot of wild plums just to eat fresh. I make *wojapi* (pudding), jelly, plum butter, and juice. Some are frozen for later use. I have dried plums before, but they lose some taste that way. The pits are discarded. We don’t eat the pits. For plum butter, I use pectin or cook it down to reduce and thicken it. I don’t sweeten it until the end because that will cause it to burn. The amount of sugar I use depends on how sweet the plums are naturally. If they are sour, I add more sugar.

I pick and dry red rosehips to make tea. My relatives use the rosehips for *wojapi* (pudding). I don’t pick rose leaves for tea or have an interest in them. When drying the rosehips, I pound them with a hammer. I steep the crushed rosehips (including their seeds) in hot water, strain the tea, and drink the beverage.

When picking buffaloberries, my grandma, Millie Arrow Side, had a canvas with hooks for the corners. That way, we caught the berries that dropped to the ground. She had equipment. Buffaloberries were especially important. When picking those, we would get wood for the stove and mint leaves for tea. We picked whatever was in season, so that we didn't waste a trip. We went out with a team of horses and a wagon until the late 1960s. A story that she told me was that there was an old lady who lived not too far from them. That neighbor would holler to Grandma, "Those are my cherries!" Grandma would yell back, "They belong to everybody!" They belong to whoever is there first, I guess. We picked buffaloberries and chokecherries, but I don't remember other fruits.

Mostly grandma dried the fruits. She also baked a lot. You didn't talk unless you were going to eat or there was something you needed to say. Chatting was discouraged. We lived close to a river, and we had the garden nearby. Morning and evening, my brother and I hauled water in coffee cans to the garden.

Wild fruits were not part of the garden. Grandma showed me where the wild fruits were. We drank river water, and later they told us we should go to a spring or well and get our water there. Now, the spring's still there, but the cattle have damaged it. The water just runs down the hill.

After I grew up, I learned from my mother-in-law, Ellen Pratt Moran. She did picking, canning, and drying. She was a small lady. She'd climb the grapevines up in the trees. Everyone was scared for her at around 98 pounds.

I went to many preservation or Extension office programs. I even taught how to make jelly and salsa, and how to preserve food by drying or canning, for example. I went to Bootstrap meetings to see how people were trying to help themselves or to preserve culture. Every couple of years something of that sort comes about. Among my friends, they don't have much interest in it. Everything is so instant in this day and age. It takes time in the summer when the fruits are in season.

I married into the Moran family. They are ranchers and farmers. So they were into gardening. I would like to garden the traditionally edible fruits. It's not a money maker, but it could be. I think we should try to plant sage, too. That could also be a business. You pay for a business site from the tribe. My cousins and aunt are coming to the fair. They have good stories.

AN INTERVIEW WITH NELLIE EAGLEMAN BLACK OWL (15)

In recent years, with adequate precipitation, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild plum, and rosehips.

For buffaloberries, I eat them fresh or make *wojap*i (pudding) and jelly. The process for *wojapi* is to boil the berries with water, strain them in a colander, add a little sugar, and thicken the mixture with corn starch. I make jelly without Sure-Jell. I grind the berries in a blender, boil in water, strain in a colander, and add a little sugar. For *wojapi*, I thicken the mixture with corn starch. I eat fresh buffalo currants or make *wojapi* the same way as that made with buffaloberries.

Concerning chokecherries, I make jam and wojapi (pudding), as well as juice with sugar to serve to the elderly to honor them. The chokecherry *wojapi* is made the same way as above, but the fresh berries are crushed with rocks. They are formed into patties and dried outdoors on cloth for about three days. The dried chokecherries are reconstituted later by adding water. They are not canned. I teach my grandchildren to drink the juices of all of these fruits. In addition, I make *wasna* using the following dry ingredients: beef, chokecherries, flour, and raisins. We eat it like trail mix and store it in Ziplocs. We carve some chokecherry sticks to make the circular frames for dream catchers, a kind of wall ornament, but we don't make many.

With wild plums, I make *wojapi* (pudding) and jelly. I cook the plums a little and remove the pits. I use the skins in the jelly. I freeze plums for later use, but I don't freeze the other fruits.

I make rosehip jelly but not tea. The rosehips are picked when red and are then boiled in water until they are the right color. Some people don't like the taste of the tea.

My mom died when I was seven. I was raised by Auntie Katherine Bone Shirt. She liked the traditional fruits. We were in boarding school and went home in summer on break. She sent us out to get fruit. At the home place where she lived, there were 25 adults and children when we weren't in school. It was a *tiospaye* (family group). Some lived in tents, others in trailer houses, and some in her transitional house in the late 1960s. Sometimes the guys went hunting deer or fishing at the creek by the trees. The kids would go along and check for berries and swim at the spring. I picked berries down by the creek where Grandpa Tom Bone Shirt lived. They'd tell us to pick berries because they made *wojapi* (pudding) to serve after a soup meal. She'd boil the berries right away and use flour in hers. It tasted good.

That's what I want to teach my grandchildren now. They pick for a while and eat it. I say, "We have to fill up this bucket." They get thirsty when they eat too many raw chokecherries. The currants are the juiciest ones. They like those. We all own a piece of land, and I have 2.5 acres. I want to plant a garden there near the chokecherries and buffalo currants. There are plums near my homestead, but there are none there this year.

I do want the grandchildren to know that I go picking turnips, and I am showing them how they look. I have to get them when they are just right. This year we are doing pretty well. I dried those for winter. I braid them. I cut them in half and use them for soup. I want to show the grandchildren what we used traditionally, including mint tea, sage, and prairie cone flower. Some say we shouldn't look to the past. But I think our culture is important. I want people to know that our tradition and our Lakota language won't be lost. It is taught in school, and I teach at home when I can. It's fun when my grandchildren know what I am saying in Lakota.

AN INTERVIEW WITH STANLEY LITTLE THUNDER (16)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

I help pick those fruits. Women cook them. I don't know what they add when they prepare them. I help dry them. I eat buffaloberries raw or made into *wojapi* (pudding). We freeze them, too. I eat fresh buffalo currants, as well as jelly and jam. We also dry them. Later they are rehydrated and used.

Concerning chokecherries, I eat them raw or dried, as well as in jam, jelly, juice, *wojapi* (pudding), and *wasna*. Some chokecherries are frozen, and others are dried. I help grind them and make patties. We dry them outside and place them on cloth. After three days of drying, they are wrapped in cloth. Some berries are ground and then frozen in Ziploc bags. I don't make crafts from chokecherry wood.

I eat fresh wild grapes, as well as in jelly, jam, and juice. For wild plums, I eat them in jelly, jam, syrup, and *wojapi* (pudding).

I started picking wild fruits at about age seven in about 1965 or 1967. We picked buffaloberries, buffalo currants, chokecherries, grapes, and plums. I would ride horses or walk around to collect the fruit. I went with Mom and Grandma, my brother, uncles, and sister. They let me help pick. We often got three or four, five gallon buckets of berries. They put down boards to avoid poison ivy when picking. We went by wagons and horses in the first days. After that, we went in trucks and cars. I kept on collecting wild fruit and never did quit. I show others how to do it because it's important. It would be a strange funeral without *wojapi* (pudding), in particular.

Of course, the berries are free and have different flavors. When I am collecting food from wild plants, I start with turnips and go through the season and see which berries are ready. It would be good if it were commercialized. I would buy chokecherry jelly and traditionally edible fruit products if they were available. My favorite berry is chokecherry because they easy to pick and taste best. I like the *wojapi* (pudding); it is better than jelly.

AN INTERVIEW WITH SAM HIGH CRANE (17)

In a recent year with normal rainfall, I collect and eat buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

After we collect wild berries, about half are used fresh and the other half are frozen to use later. I eat fresh buffaloberries, freeze some for later, and make *wojapi* (pudding) and jam after freezing bunches in Ziploc bags. When I worked for the St.

Francis Mission, I taught kids to pick buffaloberries and to make *wojapi* and jam.

Concerning buffalo currants, I eat them fresh, freeze some for later, and make *wojapi* (pudding) from frozen berries. I don't make jam or jelly. I don't dry buffaloberries or buffalo currants. We make dream catchers with buffalo currant twigs. Kids take them home for wall ornaments. They make little ones for windows or cars.

I eat fresh chokecherries. That dries out the mouth and makes teeth temporarily brown. They're supposed to be good medicine. After picking chokecherries, in recent years, we take them home and smash the fresh berries by putting them through a metal meat grinder. When I was a kid, we pounded them on a wood table with a wood mallet. Some used rocks to smash them at that time; however, we used a cone shaped piece of wood that was hard--like oak. We formed the crushed berries into patties and dried them on screens or canvas for a couple of days, depending on the weather. Then we put them into a cloth bag and stored them. We don't freeze the dried patties. We canned chokecherry juice in the old days but not as much now. At my house, we turn the dried chokecherry patties into *wojapi* (pudding) and juice. We don't can, but we process them right away. We take them out of the freezer to go to a ceremony. We mash it all up and get the juice out and take it to a ceremony for medicine. We collect only so much to make *wojapi,* and then we bag and freeze the berries. Later, we make whatever we want. It could be used for jam, juice, or *wojapi*.

I don't like to pick wild grapes because they make my lips itch and puff up. In my younger days, they picked them to make jam. They tried to make wine. That's about it. I never really got into grapes.

Concerning wild plums, I eat them fresh and make *wojapi* (pudding) and jam. I rank buffaloberries and plums at the top for taste. I like chokecherries in syrup form—but I like the others better. We also remove the pits and dry the wild plums to use later on. The branches of plums don't break very easily. You can use them for dream catcher frames, too.

I never used wild roses or rosehips. My grandmother would go and get rose leaves and mash them and put them on a cut or sore. I had a big cut on my thumb in the late 1940s, and she used that.

My great-grandmother was blind, but she taught me well. I think she was born in the 1860s. She said she was about nine years old when she ended up at Custer's Last Stand. She died in the early 1970s. Her maiden name was Laura Hollow Horn Bear. She was the daughter of Chief Hollow Horn Bear. Her married name was High Crane, but when she got into enrollment the name became Kills In Sight.

When I was a child, my grandfather, Noah Kills In Sight, taught me how to make arrows out of chokecherry wood. We put a bunch of small, green chokecherry branches together while they were drying, to keep them straight. Then, when they were dry, we used an arrow shaft straightener to finish up.

I was told a traditional Lakota story about chokecherries, wild roses, and Iktome. The point of the story is that when people sometimes tell you things to help, you should listen, because they are telling the truth to help you avoid pain. Ikto, a short form of the name, is a liar and cheater. Way back in time, when the Lakota first came out of Wind Cave, Ikto was there. He was one of the ones who got the people from beneath the surface of the earth. Because the people believed in him and followed Ikto, today everyone has a little part of Ikto in them. Ikto could be on the bright side, and in the flip of the moment he can be something else---like people are. Even the best people, they flip, you know. They lie, cheat, or whatever the case may be. We all have a little Iktome in us. Don't be like Ikto and try to outdo the other person by lying or outdoing the other person at what he does best. The following is the story.

> Iktomi (Ikto for short) was walking along, and he came to a chokecherry bush. He asked the chokecherry brush, "What do they call you?"
> The bush said, "I am the chokecherry."
> "What good are you?"
> The chokecherry said, "Well, when you eat me you get your insides doctored."
> "What else?"
> The chokecherry replied, "Well if you eat enough of me, you would plug yourself up."
> So, Ikto said, "What nonsense. See if I get all plugged up!"
> So, he ate a whole bunch. He walked along and came to the rosebud bush and told it, "What are you? What do they call you? Why all the thorns?"
> The bush told Ikto, "It is to protect me from harm."
> Ikto told the rosebud bush, "What are you good for?"
> The rose said, "If you have open wounds, you can use me to doctor yourself. You mash up the rose leaves."
> Ikto said, "What else can you do?"
> The rose said, "Well if you eat enough of me, you will get an itchy butt."
> Ikto says, "That's nonsense! See if I get an itchy butt if I eat a whole bunch."
> Ikto talked to a third kind of fruiting plant, and it told him that eating too much of it would cause stomach gas. So, anyway, Ikto was all filled up with these three fruits: chokecherries, rosehips, and one other kind.
> He went home and lay around. Soon he began passing gas and had to go to the bathroom, but he could only pass gas and had an itchy butt. Soon he ran out along the river, and he rubbed his butt into the sand. That didn't help, so he got on the branch of a tree, and he kept scratching and passing gas. He could not make it stop. He had all the problems at the same time, because he wouldn't listen to the plants and believe them. That's the end of the Ikto story.

I think the wild plants work as a medicine. My great-grandmother told us that all the flowers and fruits are medicine. So, throughout the whole year, that's why they preserve all these, so that they can use them through the winter. When my great-grandmother took water from a stream, she took some in her hand and put it on the ground and asked that the plants could grow and that we could grow strong. I live through those kinds of beliefs.

There was a time when I came to a St. Francis Catholic boarding school. I had never experienced the White side of life until that time. Once in a blue moon, we would have some kind of *wojapi* (pudding) stuff that was cooked. Most of the time, we had a big garden, and we used to pick corn, potatoes, carrots, onions and other garden produce. We'd haul it back and put it in the cellar. That is what we ate. They had milk cows. The boys milked, and the girls made the butter from that. We had the milk too, of course, but it was watered down. The big pile of cement near here is the barn footing. I learned carpentry and bakery work (mostly biscuits).

The *Wasicu* (Whites) had a lot of control over us in boarding schools. When they told us things, it was like with force. We were forced to believe their way and forget our way of life. So, nobody talked about our Lakota ways because the *Wasicu* said it was bad and the worst thing you could ever believe in. They talked about being bad and getting into trouble--by maybe talking Lakota. I know I experienced some very powerful things that even today, I guess, traumatized me. They used to make us box during half-time at a basketball game. I was only in fourth game. They blindfolded us. We were half-time entertainment. Our parents couldn't say anything about it because the government gave the schools complete control (Episcopal or Catholic, for example). I talked to Father about it. I told him, "With all the money you spent in making us into *Wasicu* ways, why don't you use it in helping our children learn about Lakota ways?" So I got hired at St. Francis Mission to explain the Lakota ways. When cuts were made because of financial issues, my position was one of the many cut—but not one of the first ones. I have an AA degree and a BA degree from Sinte Gleska. I did two semesters in Human Services to work on a graduate degree. I had health problems, so I left school.

Lakota does not have a religion. It is a way of life. Some say, when you carry the pipe, you get religion. But you don't. You can pray anywhere you want. You can go way out in the boonies and be in connection with *Tunkasila* (the Great Spirit—grandfather of all –*Tun* is the oldest of the living beings—grandparent-like). *Wakan Tanka* came from Christianity as "God." When people go up on the hill and fast and sing, they make a spiritual connection to *Tunkasila*. When you go back far enough, we are all related to the first human; so we are all related. I think everybody believes that there is a Greater Power—the Great-grandfather exists. And we all came from there in different tones. Maybe we were all one at some past point in time when we all changed our ideas and ways of lives. I think that, because we have the four colors (white, red, yellow, and red) along with blue for sky and green for earth. So, how much more connected could we all be with the environment and the earth?

I was born in 1944 and was taught that we give an offering for whatever we take from Mother Earth. So, we carried tobacco, Bull Duram brand, to give back for whatever we took from her. For example, when we picked fruits, we could spread a small pinch of tobacco on the ground.

I would go pick herbs as a child. Great-grandmother would tell me what to look for. She would smell it and say if I had the right one when I got back. I say, "smell" because she was blind. So, I used to know which herbs would work good for healing or health. For example, I picked puff balls. They have a little hole and when you squeeze the ball, a powder came out. We used the powder. I put it on sores. I use it at Sundance, too. It is called *hoksi cekpa* in Lakota. That means little infant, belly button.

It's important to have an instructor in the schools to talk about the traditional ways. I used to do public service announcements on the radio during a period of high suicide rates on the reservation. I got on the radio and did a talk show about our ways back when I was a little kid. I was trying to give kids their identity, so they wouldn't be committing suicide. I talked about things they could be proud of and who they are. That was about six years ago in 2006. About four or five years ago, I got sick, and so I put it off and never went back.

AN INTERVIEW WITH ANONYMOUS (18)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild plum, and rosehips.

The women cook the fruits, and we usually get them every year. I eat buffaloberries and buffalo currants raw. The buffalo currants taste best, and then the gooseberries. I also eat raw chokecherries and like the taste. I go drink river water when I eat them during picking, because they dry out the mouth. I also eat *wojapi* (pudding) made with chokecherries or plums. Usually, though, I eat the plums raw. We don't can or dry the plums. To make plum *wojapi*, we pit them and cook with a little water with sugar and flour thickening. We just eat rosehips when they are ripe, and we spit out the seeds. I also pick raspberries. They are red or purple. We don't freeze the fruits.

I am 42 years old, and in earlier years, I watched my grandma and great-grandma make chokecherry patties for *wojapi* (pudding) and *wasna*. They had grinding rocks just for that. They dried the patties in the sun. I watched them every summer until about age 26. We used to collect wild fruits all over the place. Dad had a spot by the river, and I like to look for berries by a river. Sometimes there are bushes away from water. I fill buckets with the fruits now, and I sell some. I get ten dollars for a gallon of plums. For chokecherries, I get twenty dollars a gallon. There might be a possibility of a commercial venture involving these fruits on the reservation. There's already fry bread mix in the grocery stores.

I am most likely to see and eat *wojap*i (pudding) and *wasna* at powwows, ceremonies, and funerals. It would be unusual to go to a funeral and not be served traditionally edible fruit dishes. I like how they taste. I grew up with them. It was just part of life. I never thought of it as a traditional. Although the fruits are still important to young people, I think they are more important to older generations. My daughter is 22 and she wants to pick fruits. I pick her up, and we go picking. I go out with other family members now to pick them. If I get the munchies, I go pick the fruits in season. There are too many snakes and too much poison ivy; so we don't always take kids. Kids should be five or six before they start picking.

AN INTERVIEW WITH ANONYMOUS (19)

In a recent year with normal precipitation, I pick and eat the following traditionally edible fruits: buffaloberry, chokecherry, wild grape, and wild plum.

I just eat buffaloberry fresh, and I don't freeze or dry them. Concerning chokecherries, I eat them fresh with salt, or as *wojapi* (pudding), or syrup, but not as *wasna*. For the *wojapi*, I cook the crushed, fresh berries with water, corn starch, and sugar. I eat it right away while it is warm. I freeze chokecherries for later use.

For grapes, I make wine and jelly, although I freeze some so that I can use them later. I don't can the fruits. I eat raw plums, but I don't make *wojapi* (pudding), jelly, or jam with them. The plums are most important because of taste. They are sweet. I've never seen any for sale.

I am 29, but when I was about age seven or eight, I went with my brothers and sisters to pick wild fruit. We collected buffaloberries and chokecherries. We got as many as we could and made all kinds of stuff from the fresh berries. Poison ivy was there, but we walked right through it. Buffaloberries mostly grew by the river. They grow wild all over. We went deeper into the woods to get the bigger fruits that no one got to. We took salt with us and lay under chokecherry bushes and ate them while fresh. We took water with us because they made our mouths dry. I picked mostly with my family, including cousins. We never tried to cultivate the plants. The chokecherries are most important emotionally as a brand or symbol of the culture. I would buy chokecherries if I saw them in a grocery store, for example. No one dyes with natural dyes, like chokecherries, that I know of.

It's important for my children to know about them. My oldest is ten, and he's picked since age five. We pick fruits when we go to Auntie's house. It makes my teeth brown, temporarily, and my mouth feels kind of raw. The salt kills the bitter taste.

We pick mint leaves for tea, although we don't dry it. We get sage to keep and dry for ceremonial or religious purposes.

I would expect the *wasna* and buffalo meat to be at a funeral. If they didn't have buffalo, I'd assume they could only get beef. I might also expect that *wasna* might be served at some tribal council meetings or at gatherings where they make a decision. At an event such as the powwow at the Rosebud Fair, it might not be served, because there are too many people to have enough for everyone.

My mother always went out to pick fresh stuff to make food dishes and to eat. I live in the country, and there are wild fruits nearby. Really, they are everywhere. We will go check the chokecherry bushes to see their condition. Then we go back when they are ready to pick.

AN INTERVIEW WITH ANONYMOUS (20)

In a year with normal rainfall within the last five years, I pick and eat the following traditionally edible fruits: buffaloberry, chokecherry, and wild plum.

I eat buffaloberries when they are freshly picked. Concerning chokecherries, my husband showed me how to smash them with a hammer on a table. I cook them by adding boiling water, corn starch, and sugar. We eat the dish right away. I don't make jelly, jam, or syrup, and we don't freeze or dry the berries. We pick and eat raw plums. I don't make pudding, *wasna*, or any craft items with wild plums.

I am 38 years old, and when we were kids, we looked around for buffaloberries because they didn't grow much where we were. If we couldn't find them, we went swimming instead. We used to pick chokecherries and tried to fill a five gallon bucket. Grandma would pay us for them. That is how we got money for pop and chips. That was in the early 1980s. I've never sold other berries.

I only made chokecherry *wojapi* (pudding) once, and my husband had to tell me how to do it. He told me, and everything I did was wrong. (Laughs.) He'd say, "No, like this." It turned out good. My mom showed me how to make bread and other *wojapi* with canned stuff, like peaches and canned blueberries. I boil water and then put in the fruit and sugar. I cook it until it boils, and then put in cornstarch mixed with a little cold water. That thickens the dish. We don't preserve that. We eat it right away. I don't know why it isn't for sale at the Rosebud Fair. It would be good. It is okay to make the *wojapi* with store fruit for a funeral, for example. I think it's important to pass it on to future generations. I only learned how a year ago.

Lately I haven't picked wild fruit. It's too hot and I am afraid of snakes right now. It's hard to take babies and toddlers along because of heat, poison ivy, and snakes. I don't see snakes that often, but the fear is still there.

AN INTERVIEW WITH ALTINE BLACK LANCE (21)

In a recent year with ordinary precipitation, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rose (leaves only).

I pick and eat these fresh wild fruits: buffaloberries, buffalo currants, grapes, and plums. While I haven't done it lately, I have ground chokecherries with a meat grinder to make *wojapi* (pudding), a boiled dish that includes those berries, water, sugar, and flour. With the wild roses, I pick the wet green leaves and steep them for tea. They are good anytime in summer. Concerning buffaloberries, we used to wait until they got really ripe. We would put blankets down, and with some shaking, the fruits would fall onto them.

The yellow ones are the sweetest. We're from Soldier Creek, and there aren't many buffaloberries this year. There are lots of currants, though. Grapes are hard to find. They are getting ripe right now. There are not many plums this year. We have to go way out to find them. Before, we would pick right along the road. Now we go much farther to get grapes and buffaloberries. This summer, we just picked and ate the fruits.

The chokecherries are everywhere. The chokecherry *wojapi* (pudding) is good, and with *gabubu* bread is delicious. You dip the bread in the *wojapi*. It is baking powder skillet bread and is not deep fried. It is pan fried in lard which tastes better than soybean oil.

There is an old saying that if big winds come, tie yourself to chokecherry bushes, and it will hold you. I haven't tried it. I heard it all the time growing up. My cousins used to make little whips that they used to gently get the horses going when they would ride. We don't make craft items with any of these fruits or their branches.

Mom used to make *wojapi* (pudding) out of plums. I didn't pay attention then. I am 54. I think she boiled them, took pits out, and finished the dish. I would serve *wojapi* and skillet bread for an important meal—like Sundance. I'd make regular beef, potato, corn, wild turnip soup. Raw turnips are good too. I'd serve it with Lipton tea.

In days gone by, we would walk five miles to find the best berry bushes. Nowadays, we go by car. My cousins rode their horses in the old days. For a ride home on a horse, we had to share our berries with them. They took horses to the river and swam and had fun while we worked hard picking. So that's how we got home with empty containers sometimes in the 1960s. We ate berries at the picking sites, too. So, if berries made it home, we ground them in the metal meat grinder. If Mom didn't use them right away, she would freeze the un-dried patties while still wet. We never ever canned.

I went to St. Francis boarding school from Kindergarten through eighth grade. I still see some of my classmates, and we lived by the nuns. I think they were Benedictines. There were about ten with whom I had daily contact. They taught cooking, including fry bread, but not traditionally edible fruits.

AN INTERVIEW WITH SYLVAN WHITE HAT, SR. (22)

In a recent year with normal precipitation, I eat the following traditionally edible fruits: chokecherry and wild plum. I eat both of those kinds of berries raw and in jelly and *wojapi* (pudding) that is prepared by women. They probably use Sure-Jell to thicken the jelly. For the *wojapi* (pudding), they grind chokecherries, pits and all, but for the plum *wojapi*, they discard the pits. If they have time, they pound the chokecherries on rock, rather than using a metal grinder with a crank-style handle. They cook the berries and thicken them with sugar and cornstarch. Sometimes they freeze the dry chokecherry patties. The chokecherry *wojapi* is a little bit gritty because of the ground pits. I don't make any crafts with these plants.

When I was young, we didn't have all the technology of today. We just played cowboys and Indians all day. Everybody wanted to be a cowboy! There were hills in my community, and we ran those all day long. We jumped in the river and snacked on the wild berries. Plums also come in different sizes. Along the river banks they can be bigger and yellower. Those are sweeter. Others are smaller and redder. Some purple berries grew near the natural springs, but I don’t know the name of them. They make *wojapi* (pudding) with both. They were dessert after supper on special occasions.

The Little White River was clearer before there were so many cattle here. So we could drink river water, then. When there was no electricity, we hauled our wood and water. There was a natural spring for bathing and drinking. They put a pipe in it. I picked and sold chokecherries and plums. I was young enough that I could pick them quickly. I picked turnips, chokecherries, and plums, but I don’t today because of lack of time, and I am not as young as I was.

I went picking with my mother in the 1950s. She showed me what to pick, mostly chokecherries and plums, and what not to pick. We tried the wild grapes, but they are sour. We avoided poison ivy the best we could. In the morning and evening, poison ivy gives off a mist. So, it is even more dangerous then. We really watched for rattlesnakes. There were a lot of bullsnakes. I don’t kill bullsnakes because they are territorial and usually there are not rattlers where the bullsnakes are.

I didn’t get into my culture until later in my life. I was raised in the Episcopal church teachings. My mother wanted me to marry a native girl, so I could have native grandchildren. She said that after she was gone, I could get involved in Lakota culture. She said that religion is nothing to toy with. Her request was that I stay away from our traditional religion while she was alive. I learned about those traditions after her death. She got her wish, Lakota grandchildren.

Part of being involved in these fruits is keeping my culture. These fruits are served at many traditional activities, such as a powwows or naming ceremonies. When there are too many people at an event, sometimes they cannot serve the traditional foods because they might not have enough for everyone. They are served at the Sundance or a sweat (*inipi*). They are also served at funerals and *yewipi* healing ceremonies where traditional fruits might be served. For health we use bitterroot and sage. I have a friend from Pine Ridge who is a medicine man, and he looks for those.

I am grateful that I got the education I got on the Rosebud at Sinte Gleska. I do a lot of public service announcements for the university. I translate to Lakota and put it on the air. I get support from Elders, and they complement me on how well I got my message across to them in Lakota language.

AN INTERVIEW WITH ANONYMOUS (23)

In a year with normal rainfall in the past five years, I have collected and eaten the following traditionally edible fruits: chokecherry and plum. I eat both kinds of berries in their raw state. I also eat chokecherry *wojapi* (pudding).

I don't make *wojapi*, but my sisters do. They probably thicken it with flour. I am not sure what they do with the pits because I never saw how they handled that. No one showed me how to make it. Sometimes we put it in the refrigerator. The berries are used fairly quickly after they are picked. I don't make craft items from the plants.

When I would go swimming, I would pick them to have something to snack on. The berries are good for you, and they grow all over the place. We take our kids out and pick them. The berries are not available in the same place every year. We pick ice cream buckets full of the berries. Most of the time, there's no poison ivy where we pick them at Dad's place. If we see poison ivy where we pick, we take the kids home, although sometimes they do get into it. We put on calamine lotion and give them children's Tylenol.

Mostly, the wild berry dishes are served at ceremonies, sweats, and wakes. Sometimes people have them for regular supper or dinner. It is really important to keep for our traditions. If you don't know how to live off the land, it's a waste. It's as important as language and native religion because our grandmothers and mothers had those traditions. I don't know of anyone who uses traditional plants for dyes.

We moved here from Denver when I first found out about the uses of traditional fruits. We were just walking around and swimming, and my sisters and cousins told us about the berries. I was about eleven or twelve at the time. I am 26 years old. As I get older, I will pay more attention to the traditional fruits. At the present time, my older sisters collect and cook them. I will learn from them. I intend to pass on to my children the picking of fruits and the making of traditional foods. They are ages seven, six, and four, and the baby is one. It's important that our kids remember what to look for, what to pick, and family time to get together. That part of traditional knowledge needs to keep going on. It's stupid to say that we need to forget the past and history. It's still here, and we can find it and do something about. It's pretty much guaranteed that some family member would bring traditional fruit dishes to a funeral.

AN INTERVIEW WITH LARRY BLACK LANCE (24)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, chokecherry, wild grape, and wild plum. For the most part, I eat them fresh, just after picking. Occasionally, I eat chokecherry or plum *wojapi* (pudding) when I am visiting others at their homes.

I pick and eat these fruits when I am out walking. With the exception of wild plums, I don't take the berries home in buckets. I leave plums in the house until it is all eaten. I don't have the sweet tooth I had when I was younger.

We are losing some of this part of our culture. I would go with Grandma Rose Kills Plenty to pick berries and stuff at nine or ten years of age. When we got home, she had a big stone that was round and indented and also an upright pestle stone that fit her hand. She would grind the berries, form them into patties, and put them on paper to dry in the sun. Then she hung the patties on a clothesline near the house. My sister's name is also Rose, but it is a name you don't hear much anymore on the Rosebud.

Grandma took me along to pick ripe buffaloberries. She placed a sheet on the ground under the tree, and she shook the branches. The berries fell to the ground. We'd gather big buckets of berries in that way. It was really fun. All the grandkids were there. That was around the 1970s. It was a family thing, not something that included friends. There were lots of spots where we lived. There's a spot where plums are really large. The plums there are the size of ping pong balls. Sometimes Grandma made *wojapi* (pudding) with canned fruit, too.

I went away to Idaho at age eleven. I'd go away for a year and come back here for a year. Grandma passed in 1982. We flew back for that. She wanted to see me before she died. We haven't really gotten into it since she passed. It makes me think of her when we go picking. It would be important for her to know that we are carrying it on. We learned from her. We explored out in the hills. We'd get hungry and know what to eat. At her house, she had a propane cook stove; however, there was an old-time cook stove outside. She'd cook out there in the summer. So I had to get firewood for that. Every day she made biscuits to eat. She made mostly chokecherry and buffaloberry jelly to spread on the bread. I liked the chokecherry best.

AN INTERVIEW WITH ALOYSIUS RUNNING HORSE (25)

In a year with normal rainfall, I use the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, and wild plum.

I eat the raw buffaloberries, buffalo currants, and plums when they are freshly picked. Concerning the chokecherries, I eat them raw with salt, and we make juice and grind them into patties that are dried. They are stored in cloth bags, so they don't mold. We also freeze them. Eventually, those patties are made into *wojapi* (pudding). I don't cook, but I help, up to that point. I don't make crafts from any parts of those plants.

Mom and Dad took me and my brother and sisters to pick chokecherries in the late 1960s. It was fun. We also went swimming. We would have to drink water because the chokecherries would dry out our mouths. We would look for a clear spring.

They'll never stop collecting wild berries. It's the traditional way. It matters. My mom's parents collected berries a long time ago; so she passed it on. I always tried to keep traditional foods at the level of importance of native religion and language.

These foods show up mostly at ceremonies. For example, at *yewipi* (healing) ceremonies, I expect to see chokecherry *wojapi* (pudding). Once in a while it would be plum *wojapi*. I don't remember those foods being served at funerals that I attend.

I went out by myself to pick berries last summer and this year. It's good to hike, to think, and to be in nature. I was riding a horse and looking for other horses and saw a good patch of chokecherries and said, “I’m going to pick some.” I collected about two gallons. I sell them for ten dollars for an ice cream bucket full. I carry them around and let people know I have them. I don’t collect other plants.

The older people seem to be more interested in these matters. Today, you don’t see as many children, teens, and twenty-somethings involved with the fruits. I think it is important for them to know what to collect, where to go get it, and how to prepare it. For example, at a healing ceremony, raw chokecherries are served to everybody there, including the sick. We spit out the pits.

If the traditional fruits were made into foods or beverages and available at a grocery store, and made on Rosebud, I’d buy them. I would rather have such foods made by Lakota so that the taste is right. I would want the product to be like I expect it to be.

AN INTERVIEW WITH CLAYTON HIGH PIPE (26)

Recently, in a year with normal rainfall, I use the following traditionally edible fruits: buffaloberry, chokecherry, wild grape, wild plum, and rosehips.

I eat all of those fruits raw when they are freshly picked—some more than others. Concerning chokecherries, my mother, Emma High Pipe, makes jam, cans juice, and dries the ground patties outside for a week. Then she freezes the patties. The berries are pulverized with a metal meat grinder. She makes chokecherry *wojapi* (pudding). Sometimes I use the chokecherry wood for frames for dream catchers. They are not made to sell, but rather for family and friends.

For plums, Mom removes the pits and makes jelly, jam, and *wojapi* (pudding). She doesn't freeze or dry the plums. I occasionally pick and eat red rosehips when walking through the prairie.

I am 45 years old. I don't know how to put this, but when I was growing up on the reservation, I had nothing in my life, not even electricity. We just had a wood stove. We cooked fish, turtles, and frogs, and we collected all the berries we could see. They were energy. We needed the food. It was survival. In the 1970s, we lived on the prairies with no car and no horses. We had no lights. All they had were candles. Mom cooked outside on a bonfire. We had no propane. Mom would say, "Go fishing." Do you know what a safety pin is? Well, we used those for fishhooks. We dug our own worms for fishing. We would wrap string around a stick and use a rock for a fishing weight. Nine kids lived in our home with mom. My brother and I were the youngest.

Then I went to live at the Bureau of Indian Affairs dormitory at Mission. I only stayed there for two years, and then Mom got a house. Things were better at the house. Then I learned to make *gabubu* bread, fry bread, *wojapi* (pudding), *wasna,* jelly, and jam. She said to me, "You are going to be a man someday and have to take care of your family. You need to know that." She knew I would have children and would take care of them. "Don't be a crook, just be a cook," is my saying.

I think it's better in life if you take care of your health, and that can include traditional fruits. It should be taught in schools. They need to know where to go to collect the foods, when the plants are ready to harvest, how to prepare, and how to cook them. It would be good for parents and grandparents to take kids and show them. There are some plants that will make you sick, but not the ones we are talking about here. So they need to know the difference. Other plant parts to collect are turnips, the fleshy red part on cactus, raspberries, and mint tea. I would choose to go through my early life experiences again, because the experience brought me intuition and taught me how my mind works and how life really is.

AN INTERVIEW WITH GREG QUIGLEY (27**)**

In a year with normal rainfall, I use the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild plum, and rosehips.

It is common for me to eat the fruits raw. We freeze all of those that are not used fresh. The chokecherries can be ground after they are frozen and thawed. We can the juice to use year round. Mostly, I make the *wojapi* (pudding) from either chokecherries or plums, and I make *wasna* from chokecherries. For the chokecherry *wojapi*, I put the pits and berries through a metal meat grinder, and then I boil it with sugar and flour. The women make the jam and jelly from the fruits. The only thing we make from the rosehips and rose leaves is a tea beverage.

My grandma, Lucy Bear Shield, and my grandpa, Thomas Red Bird, taught me what to do with traditionally edible fruits. Presently, I am 48 years old. When I was four, they taught me about how healthy these fruits are. They took me along picking berries. They taught me how to process them, because they did all that. I learned from them about the ways of long ago. When my mom was alive, she taught me and said, “Don’t lose those traditions, or you will lose your life.” I didn’t give them up.

I was about twelve or fourteen years old when I went out and got chokecherries and plums with other kids. We also went swimming. We kept eating the fresh berries until we had overdone it. We all got very sick to our stomachs. We still tell that story when I am around them. Sometimes I still eat too many, and it makes my stomach upset. I eat that many because they taste so good. I didn't learn from my young experience. I like them that much.

There are religious stories about chokecherries and buffaloberries that we don't talk about because they are sacred in nature. I know many of those stories, but they are not to be recorded. We expect to see some of traditional fruit dishes at certain events such as ceremonies like sweat lodges, Sundances, funerals, healing ceremonies, and others.

AN INTERVIEW WITH ANONYMOUS (28)

In an average year, recently, I use the following traditionally edible fruits: chokecherry, wild plum, and rosehip. While I live on the Rosebud Reservation, I am enrolled as a Santee in Nebraska.

For chokecherries and plums, I eat them raw or dried with salt. Sometimes I make them into jam, syrup, or *wasna*. With plums, I also make *wojapi* (pudding). Dried rosehips are used for tea by steeping them in boiling water.

To prepare the chokecherries, the berries and pits are ground in a metal meat grinder. They are then dried or frozen. They can be used wet when they are freshly ground, too. The plums are not dried. The pits are removed if they are used right away. If they are to be used later, they are frozen and then boiled and the pits removed at the time of use.

My *wasna* is dry like mueslix. I use ground and dried chokecherries or pitted plums with water, sugar, corn starch, and usually raisins. I dry it in the oven for ten minutes at 350 degrees. I store my *wojapi* (pudding) by freezing. For jams, I use Sure-Jell and corn syrups. I do not can the foods I make. I would buy chokecherry jelly, for example, if it were for sale at a grocery store.

I love to pick buffaloberries and chokecherries with grandchildren. We used to go to Little White River by Old Ring Thunder. They'd swim too. There are lots of plums and chokecherries out there. We take ice cream buckets for collecting, along with a lunch. I show kids where poison ivy is, so they stay away. I wear a long sleeved shirt. I put all the chokecherries and plums in water to rinse them off. The kids eat while we pick. It turns their teeth brown, temporarily.

I went riding horses in the 1980s, and we used to pick the berries and plums, and we brought them back home. When kids and nieces and nephews would say they were hungry, I'd say, "Let's go picking berries." It was a family outing involving hiking.

My mom told me that a long time ago they'd pick chokecherries and buffaloberries down by river, and she said how long it took them. She's traditional. Mom would go picking all day in the 1950s. I went picking with Mom and my aunties after that.

I would expect to see traditional fruit dishes at wakes and funerals. They might show up at birthdays or any ceremony, too. It is important to save the traditions, about as important as saving Lakota language. It's family. It's part of the Indian way for grandkids to learn about the fruits and eat it. About age five is a good time to get them started. It is good to show them where to find the fruits, what colors to look for, and when it is ready to eat. They need to know how to save it and prepare it. It makes me happy to know about those ways. It is respect for my mom and grandmas and aunties and sisters.

AN INTERVIEW WITH AUDREY BEAR DOG (29)

In an average year in the last five years, I used the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

I eat buffaloberries raw, but not salted. I also make *wojapi* (pudding) but not jam, jelly, or syrup. If I get too many berries, I grind them with a metal meat grinder. Buffaloberries are hard to get, though, and it takes a while to pick them. I would freeze the extras and grind those later if I want to. I don't know how to can but want to know how.

With buffalo currants, I eat them raw and also make *wojapi* (pudding). I mash them and then cook them with water and sugar. Then I thicken the mixture with flour or corn starch. That is eaten right away.

Concerning chokecherries, I eat them raw without salt. I also wash some and freeze them. Then I take some of those and grind them in a metal meat grinder. The ground berries are dried outside. I also dry sweet corn. I make *wasna* with ground berries, dried meat (beef, buffalo, or deer) that is all smashed with a mortar and pestle from Mexico, although I got it in Utah. I also add kidney fat, sugar, and raisins. The grease moistens it. For chokecherry *wojapi* (pudding), I combine ground berries, water, sugar, and flour or corn starch. I boil that down, like pudding. I don't make jam, jelly, or syrup, but I make juice and drink it. I have the last of my chokecherry taffy candy in my backpack, but I don't make that. The chokecherry twigs are good for making frames for dream catchers wall hangings.

For wild grapes, I rinse and mash them and cook them with sugar to make *wojapi* (pudding). They are too bitter to eat raw. I don't make grape juice. If I have extra, I freeze the grapes in case I want to make *wojapi* later. I also make *wojapi* with wild plums, and I eat those raw because they are sweet.

I am often out picking because it's a family tradition. For those who aren't afraid of poison ivy, poison oak, or snakes, I suggest they go up into the canyons and pick. They will have a supply of food for the winter.

I always like to tell this bedtime story to little kids. It is about the beginning of time, and maybe these fruits lived in the water. Who knows, at the beginning of time? The story includes beaver and brother spider. They got bored, and between the two, the beaver is the hardest worker in the world. It was the spider who told the beaver to take this mound of dirt and add it to another pile, until the dirt came up above the water level. Brother spider told brother beaver, "I will tell you long, short, and other stories as long as you keep picking up mounds of dirt and adding it to the pile." They created a new world that way above the water. Soon they got bored again, so they went back into the water and got their brothers to join them in the new world they made. (By that time the kids are usually sleeping.) The point of the story is that they had to bring the food up out of the water to have it above ground.

Keeping the food traditions is important, like our language and religion. They use those foods in ceremonies or honoring things or healing. They are for big dinners, too.

They have always been known and passed down. They are sacred, and that is why they are used in ceremonies. Not all foods are ceremonial, but they can be.

I use them as a preventative to keep me strong and healthy, and they taste good, of course. I think they are useful for colds and flu because they have a lot of vitamins. All food comes from Mother Earth and has a kind of spiritual connection because of that—not just these foods. It is from ancient tradition that these are served at funerals—things that those who left before us always enjoyed and used. It honors them. It wouldn't be unusual for buffaloberries, buffalo currants, chokecherries, or wild plums to be served at a funeral. Chokecherry is the most likely.

For young people I would say that from the beginning of time our people lived this way, making use of these. So, they should too. They should think of their health and the unique taste the berries have. I encourage them not to lose the tradition.

When I pick today, I take along one or two grandkids or my cousin. She has a car. Otherwise, I walk near my place and get the berries there. My sons and cousin also dig wild turnips. I pick wild mint for tea and another wild green plant for tea—perhaps that is leadplant. I am not sure what you call that. I used to pick sandcherries, but not now.

AN INTERVIEW WITH ANONYMOUS (30)

In a recent year with average rainfall, I eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

I eat buffaloberries raw, but I also make *wojapi* (pudding) with them, as well as with buffalo currant, chokecherries, and plum. I don't mingle the different kinds of berries. I boil the berries, and add sugar and flour. I don't can or freeze *wojapi*.

For chokecherries, I also eat them raw or dried. I grind the fresh berries and form them into the shape of hamburger patties. I put them outside to dry and put them in pillowcases to store them for later use.

For the wild grapes, I eat them raw or in jam or syrup. When making the jam, I boil the berries, strain out the pits, sweeten it, and thicken it with Sure-Jell. I put it in jars with wax on top.

I eat wild plums when they are fresh or dry. I make plum *wojapi* (pudding), as mentioned, as well as *wasna*. I freeze the whole plums, including the pits. They are pitted when they are later thawed and used.

I eat raw rosehips when they are ripe. For tea, I use both the hips and the rose leaves. I dry them and steep them in hot water for tea.

My grandpa, uncle, and the family used to paint faces with chokecherry juice to dance. It washed off easily. My grandma told me that she died porcupine quills with chokecherry juice. They would teach us kids and tell us what to do to smash the chokecherries on a big bowl-shaped rock. We had a round rock that was hand held to smash the chokecherries. Then we'd dip our fingers in the juice and mark our faces with it. All the kids had a good time doing that in the 1960s. We also ate the crushed berries. There was no sugar added because we never had sweets. It was our treat.

All of us kids and the family would go out and look for berries. Mom and Dad would say, "Here's a tree and there is your bucket." Then they'd go home. They would tell us to pour the berries into five gallon buckets and go pick more berries. The grandmas were at home grinding the chokecherry patties and drying them. They kept some for *wasna* and some for *wojapi* (pudding). None got wasted. We picked wild plums and chokecherries in the 1960's that way, too. We did not crush plums. We were heavily into drying the wild fruits—not using freezers. It was part of getting ready for winter. They got sweet corn ready, too, by drying it and crushing it. We did not can.

We also collected wild turnips, onions, raspberries, and mint leaves for tea. We hung the tea around the porch in bundles. When it was dry, the leaves were crushed and stored in coffee cans.

I go out with my kids today. They are teenagers now. This summer we looked once and didn't find much. We got about a gallon of plums, and we got about a quart of chokecherries. That's because it's a drought year. Usually we get 30 or 40 gallons of plums a summer and 25 gallons of chokecherries.

Some years, the fruits are abundant and other years not. I hope that future generations will go out and pick. It is healthy food. A lot of people are diabetic today. We should look at how we used to eat and encourage that.

AN INTERVIEW WITH DELORES KILLS IN WATER (31)

In a year with normal rainfall in the past five years, I consume chokecherries and wild plums.

I eat the chokecherries raw, near the time they are picked. You need to watch how many you eat because they make your mouth brown, and then you need to brush your teeth! I don't make jelly or jam with them, but my mother did, and she canned them with help from cousins in the neighborhood. I dry chokecherries and use the patties to make *wojapi* (pudding). Sometimes, if I really feel like it, I make *wasna*. I only made that once, because I have a relatives who makes it all the time. So, when she's out of dried chokecherry patties, I share mine with her, and she gives back. We pound and dry the chokecherries, including the pits. I have a stone mortar and pestle that was Grandma's and Mom's, and now it is mine. We dry the patties, and hang them in a clean sack in the corner of the kitchen.

I also make six-inch tampers with scraped chokecherry twigs, and we use them when smoking the pipes. When the ashes go out, we poke them with the stick so that we can continue to smoke. We do that all the time.

Concerning wild plums, I make *wojapi* (pudding), and I also eat raw plums. When I make *wojapi* with either chokecherry patties or with pitted plums, I boil the fruit, and add a flour and water mixture to thicken it. I stir it until the lumps are out. In the early years, we hardly had much sweet food, so I don't use too much sugar, currently. In a two quart pot, I might add two cups of sugar now. We did not know about diabetes in the early days, and we didn't have a craving for sweets, then.

There are three types of *wasna*: jerky, chokecherry, and corn. My mom's recipe for jerky called for a dried piece of beef about the width of a hand and about ten inches long and eight inches wide. Buffalo would also work, but it is hard to get. We always had tallow fat, or kidney fat could be used. Mom dried the meat properly because when it is not done correctly, the food has a spoiled taste. She said that when preparing food, everything must be clean because people will eat it. She would wash her hands and the ingredients. We didn't have running water. So, she boiled the bedding and the kitchen towels. They were always clean. She took a towel and dried the meat before slicing it up to dry in the sun. She tended to the drying meat by covering it with thin cheesecloth, although I use curtains. It is important not to have flies on the meat.

To dry a large piece of meat, she would boil water and add the 8 x 10 inch slab of beef to boiling water where it remained for from two to three minutes. She then removed it from the water and put in a bread pan in a hot oven. She turned it. That moisture from the water helped the dried meat while it was baking. The meat was turned. Then it was taken out of the oven. Mom asked Dad to pound it. He shredded that piece of dried meat until it was very fine, but not powdery. I don't want to share her exact secrets of making *wasna* because someone might take the recipe and make good *wasna* and sell it.

We haven't had many chokecherries or buffaloberries lately. There are cattle all over at the places where we used to pick them. The cattle harm the trees and step on the young branches. We had plums in 1979 when I moved back to the Rosebud Reservation, but the cattle ate them. The deer ate my chokecherries. So, I told the deer, "Eat all you want. When my grandson shoots you this winter, I will have cherry flavor venison!" So, the berries come and go. There are no currants around with this drought (2012). I had all my fruit in the yard. Plums bloomed but didn't produce fruit. The wild grapes produced heavily, but the Hutterites came out about 3 years ago and traded me chickens for them. When the Hutterites don't come, I don't pick the grapes. I just let them die on the branches because I don't want the grapes. I noticed that the chokecherries next to the grapevines do not produce as well as those farther away. The vines may choke the bushes around them. Concerning wild rose plants, I don't use the hips or the leaves at all.

We also used to collect sandcherries. We picked them in Spring Creek community about seven miles south of my community, Grass Mountain. We collected in the 1960s when we visited relatives there. Dad's four brothers would hire out of a ranch at Spring Creek. They asked us to take them to the ranch during haying season. They did other work for the rancher, but this was in July and August. We would go to the sandhills and take the wagon roads and find gallons of sandcherries. They grow close to the ground, unlike the other fruits, and are about the size of plums. They are fleshy and have seeds. The Indians called them *aunyapi*. When we picked those cherries, we faced the wind because if we didn't, the fruit was sour.

My mother used to take me picking berries when I was thirteen or fourteen years old. It was hard work in July going up and down ravines. She would buy us firecrackers; so we would go. I am surprised that I didn't accidentally cause a fire. I could not tolerate canning on a hot day. Mom loved it. She canned inside our log house. One year, my dad and uncle moved a heavy cook stove outside and made an arbor, and Mom canned all the fruits we picked outside that year. One year she canned 42 quarts of juneberries. She never dried those. We picked them in June so we called them that. There was one ravine that had juneberries, chokecherries, plums, and raspberries. At that location, ranchers later leased it, and cattle destroyed those plants.

My mother sent me to all kinds of schools. So I got an education. I graduated from St. Francis in May 1949. They didn't teach us about traditional fruits there. They were trying to save our souls with basic curriculum. We had a religion class, although I am not Catholic. We learned sewing and did kitchen work. They did not can foods.

I was 25 years old when my husband came out of the military service. We relocated to take jobs picking potatoes in the 1950s. Later in my life, we moved back to the Rosebud Reservation so my two young children could graduate from St. Francis. In

1979 when we came back to the Rosebud Reservation, cattle had harmed the traditionally edible fruit plants near where I live now. I don't want to go someplace farther away to pick because it was a hard life doing all that picking.

In my lifetime, my grandmothers and mother died in their sixties. I was 24 when my mother died. She was a hard working lady, known as Grandma Winnie or Auntie Winnie. It was nothing for her to take her daughter out to pick berries. She didn't have a large family, just me and my brother. She shared what she had with her neighbors and relatives. There was an elderly man who lived two miles away. He called my mother Mom. She would share our food with his family. He would say that they were hungry for something sweet—jelly and jam. She would share flour and baking powder, too. She prepared all these goodies for him, sharing all the hard work of picking berries and cooking these foods. She enjoyed giving by preparing food in both summer and winter.

Today, people are more mobile. Some would rather have someone else pick and sell them the traditionally edible fruits. It doesn't happen too often because sometimes a person doesn't have the money to buy. Sometimes, five gallons of chokecherries could cost twenty dollars in this day and age. I think people would want it, if they could buy it. If you know someone to pick for you, you can trade yardage of material for it, too, if they will agree.

It's very rare to get *wojapi* (pudding) now. At a powwow I attended, ladies were cooking. We had traditional soup. They were going to serve us elders. I pointed at a dish that looked like *wojapi*, and I told my daughter to get me an extra serving of that. She looked at me funny and brought me an extra bowl of pork and beans! From a distance it looked like *wojapi*! It is a real treat when someone makes plum or chokecherry *wojapi*, nowadays. Furthermore, buffaloberry is a very rare dish, today, and it is hard to find.

AN INTERVIEW WITH VIOLET LITTLE ELK (32)

In a recent year with average precipitation, I use the following traditionally edible fruits as food: buffaloberries, currant, chokecherries, wild grapes, and wild plums. I don't use rosehips.

Today, I freeze and use wild plums and chokecherries. I have become modern with time, since I am not my Grandma. I use those fruits to make *wojapi* (pudding) for feasts, wakes, or whatever. I enjoy helping other people. I use the same techniques as my grandma. I measure by hand. To me all fruits are food. We also go *tinpsila* hunting for the wild turnips in the prairie.

I am an enrolled member of Rosebud Indian Reservation residing in my community named after a chief, Two Strike. I am proud to be an original member of the Two Strike Community. I grew up with my grandparents. Ever since I can remember, we always went picking fruits in July and August. I heard my grandparents tell when the fruits were ripe. As a little girl—I knew how to pick chokecherries, plums, buffaloberries, and currants. I never picked wild grapes, but my grandma did that. Her fingers turned purple from picking them. She would wear gloves, sometimes. When it was time to go picking, my grandpa would hitch the team, and off we would go—not just me— but also my other siblings. Grandma would pack a lunch, and we came home towards the evening.

My grandma canned her fruits. I remember that when I was a little girl, she used to work in a cannery in the town of Rosebud. I remember, too, that we had a big garden every year. It seemed like we lived on that all summer long. She canned whatever could be canned. For a measurement, she used her hand. So, for me, that's a cup. At that time, I don't remember any measurement utensils. As far as I can remember, mostly all the fruits can be used for *wojapi* (pudding) and all of them can be made into jam. My grandma used them that way.

APPENDIX B: FORMS FOR INTERVIEWS

INTERVIEW QUESTIONS, ROSEBUD RESERVATION

Date:----------

Interviewee: Number from 1 to 32 -----------------

Interviewer: Joanita Kant

Participant Name--------------------------------- Anonymous? No----- yes------

1. How much, in measuring cups, would you estimate that you eat of each of the following traditionally edible fruits in one year's time in an average year over the past five years?

2. How many cups of each, below, do you personally use, and are they as food, beverage, tonic or medicine?

Buffaloberry-----------------------------

Buffalo currant---------------------------

Chokecherry-----------------------------

Wild Grape------------------------------

Wild Plum-------------------------------

Rosehips (if leaves, specify-----------

3. How do you use those fruits?

4. How do you prepare them?

5. Why do you collect and use those wild fruits in this modern day?

6. Do you have a story or stories that you would like to tell about any of those fruits?

INFORMATION SHEET/CONSENT FORM

Participation in a Research Project: "Modern Uses of Traditional Fruits on Rosebud Reservation"

(distributed to participants)

South Dakota State University and the South Dakota Humanities Council

SDSU Project Directors: Bruce Berdanier and Joanita Kant

Department of Civil and Environmental Engineering, Crothers Engineering Hall 109 SDSU, Brookings, SD 57007 (605-688-5427)

E-mails: Bruce.Berdanier@sdstate.edu and Joanita.Kant@sstate.edu

Prepared: August 17, 2012

Date Please read ------ (listen to) ------ the following information:

1. This is an invitation for you to participate in a research project under the direction of Bruce Berdanier, Department Head, Civil and Environmental Engineering; and Joanita Kant, a graduate student at South Dakota State University. Information (stories and recipes) you provide may be used in a research paper being prepared by Kant as a Ph. D. dissertation and in programs of the SD Humanities Council. It will be available to the general public. Your name will be used if you give permission, or your name will be removed from your information if you select that option. Please initial one of the following concerning confidentiality: (A.) Concerning my story (initial one or the other) I give consent to use and publish my name--------------. (B.) I do not give permission to use and publish my name and want it removed from my story as soon as possible, so that mine is anonymous ---------------.

2. Participants will be adults who live on Rosebud Reservation and whose stories are of

interest to the graduate student collecting the stories. She will make the selections.

3. The purpose of the research is to collect stories about modern uses of traditionally edible fruit on the Rosebud Reservation and their role in cultural lore and the value of history. Since the graduate student is also studying certain nutritional aspects (heavy metals) of such fruits, participants will be asked about how much of each fruit they consume in an average year (buffalo berry, buffalo currant, chokecherry, grape, plum, and rosehips).

4. Participation is voluntary and the participant may withdraw without penalty.

5. The participant will visit with the graduate student for one hour, while she asks questions and takes notes. In order to make corrections, the participant will be given the opportunity to read the notes or have them read to him/her immediately after the interview.

6. The participant will complete a voucher in order to receive a check for $60 in the U. S. Mail, and will also complete a W9 form with his/her social security number in order to receive payments which will be processed by South Dakota State University Foundation. Funds are made possible through a grant from the SD Humanities Council, Brookings, SD. No payments are available for mileage or for others (not selected to be interviewed) who are in the room while the interview is being conducted.

7. The potential benefit to the Rosebud Reservation community is to produce a record of modern cultural practices concerning traditionally edible fruits that have historical connections. A copy of the stories will be made available to the local Historical

8. There are no known risks in participating.

9. The graduate student interviewer may remove any participant from the study if, in her

opinion, it is in their best interests.

10. A copy of this form will be left with the participant so that they can contact the project directors if they need to do so.

DATE PARTICIPANT NAME PROJECT DIRECTOR NAME

If you have questions regarding this study, you may contact the Project Director. If you have questions regarding your rights as a participant, you can contact the SDSU Research Compliance Coordinator at 605-688-6975 or SDSU.IRB@sdstate.edu. This project has been approved by the SDSU Institutional Review Board, Approval No. IRB-115010-EXM.

APPENDIX C: PHOTOGRAPHS

Figure C-1. Site 1, southwest of Oglala Lakota College administrative center, School Road (gravel), 2011.

Figure C-2. Site 2, north edge of the village of Manderson, SD, BIA Highway 28, 2011, Sadia Malik, Willis Zephier, and Laura Henery.

Figure C-3. Site 3, west of Wounded Knee Battleground and Cemetery, BIA Highway 28, 2011, Willis Zephier and Sadia Malik.

Figure C-4. Site 4, on the White River, west of Pine Ridge, SD, BIA Highway 32, 2011. The culvert washed out the road at the site in a flash flood.

Figure C-5. Site 5, badlands north of the USDA Landfill, BIA Highway 41, 2011, Laura Henery and Sadia Malik.

Figure C-6. Site 6, near Badlands National Monument visitor center, BIA Highway 2, 2011.

Figure C-7. Site 7, near Redshirt, SD, BIA Highway 41, 2011, Laura Henery and Sadia Malik.

Figure C-8. Site 8, near Potato Creek village, SD, BIA Highway 2, 2011.

Figure C-9. Site 9, badlands south of Kadoka, SD, State Highway 73, 2011, Laura Henery and Sadia Malik.

Figure C-10. Site 10, near Brunsch Ranch, State Highway 44, 2011.

Figure C-11. Site 11 on the White River, northeast of Chadron, NE, U. S. Highway 385, 2012.

Figure C-12. Site 12 on the White River, west of Oglala, SD, U. S. Highway 18, 2012.

Figure C-13. Site 13, on the White River, west of Badlands National Monument visitor center, north of Rockyford, SD, BIA Highway 2, 2012.

Figure C-14. Site 14, Carlbom Ranch on White River, south of Interior, SD, State Highway 44, 2012.

Figure C-15. Site 15 along the White River, south of Kadoka, SD, State Highway 73, 2012.

Figure C-16. Silver buffaloberry. From a distance, it looks like Russia olive because of the similarity in leaf color. Of all the fruits of interest, silver buffaloberry mostly failed to set fruit in 2011 and 2012.

Figure C-17. Buffalo currant is also commonly known as golden currant because of showy yellow flowers.

Figure C-18. Chokecherry, with remaining bloom remnants, are starting to set fruit. Among the Lakota, chokecherries are probably the favorite, followed by plums.

Figure C-19. Wild grapes beginning to set fruit. When ripe, the fruits are purple with a white dusty haze.

Figure C-20. Wild plum thicket at Potato Creek Site. David Fisher of OLC and Sadia Malik of SDSU collect a soil sample.

Figure C-21. Wild rose in full bloom. This is the tallest of the wild rose species on PRR and one of the most common, Woods' rose.

APPENDIX D: ARSENIC, ICP-OES RESULTS

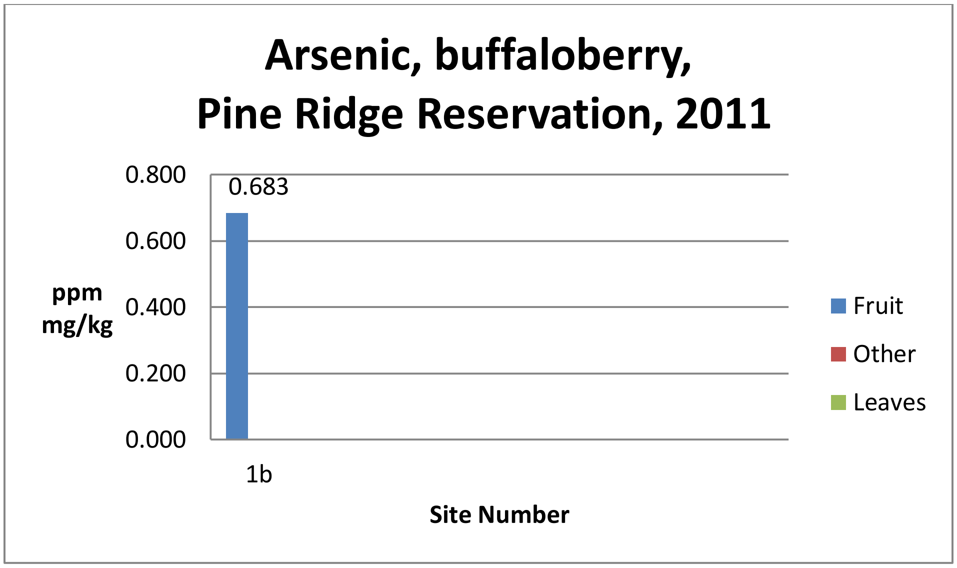
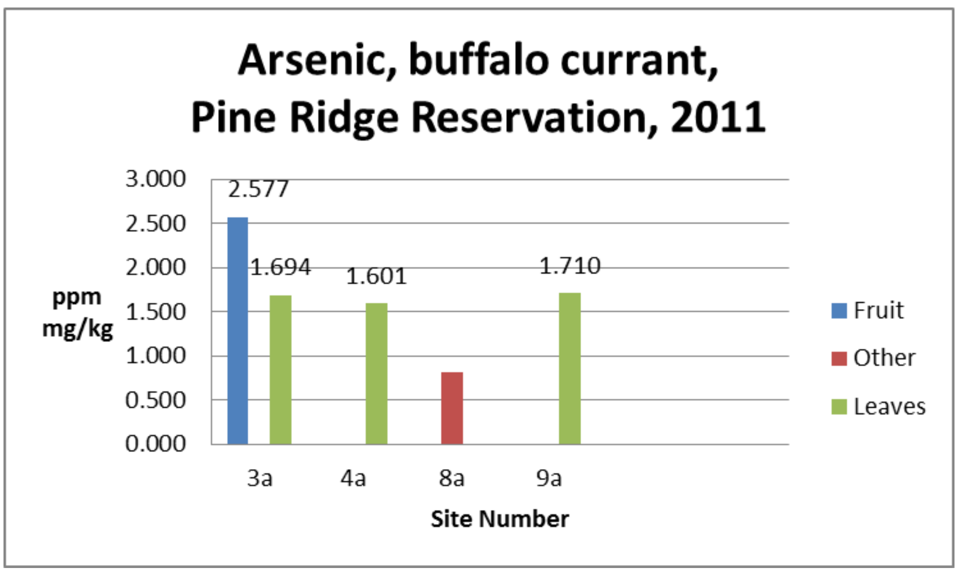


Figure D-1.



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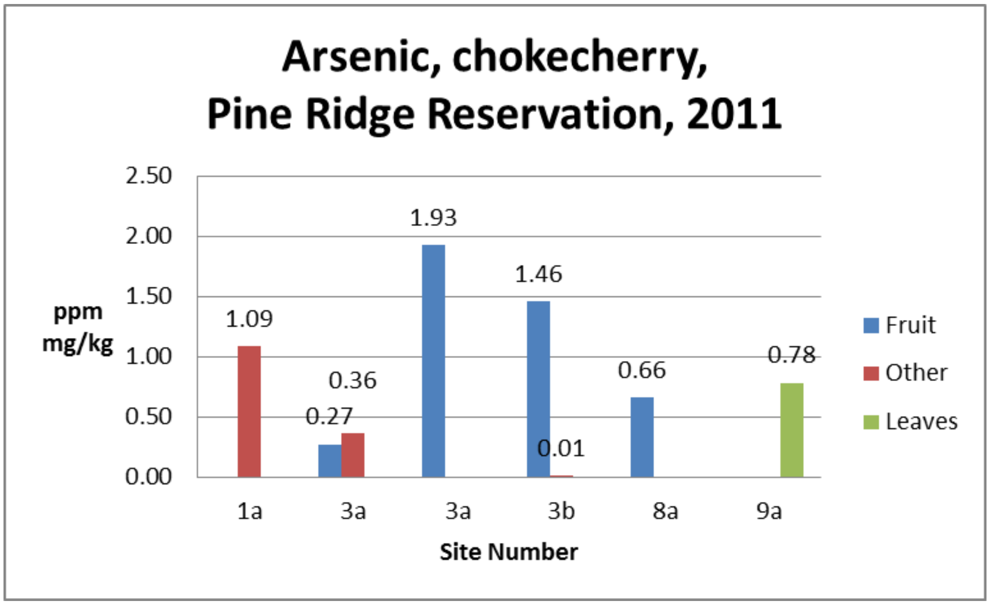

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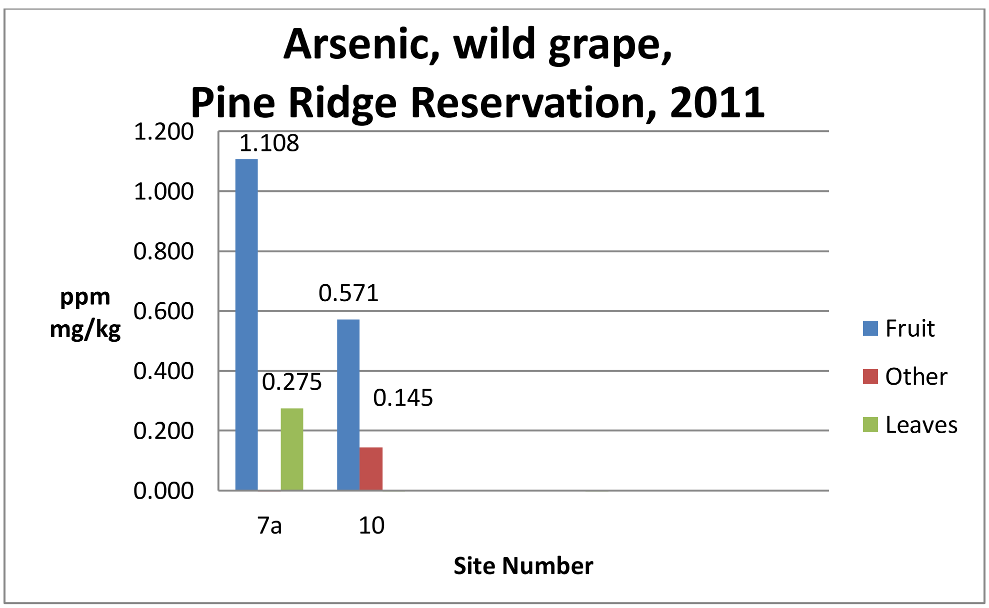

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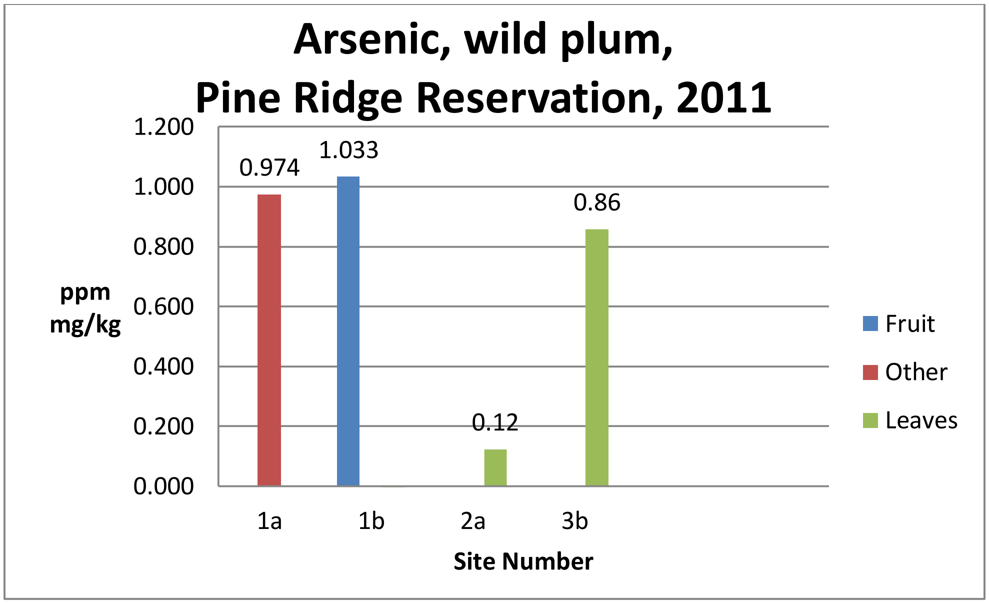

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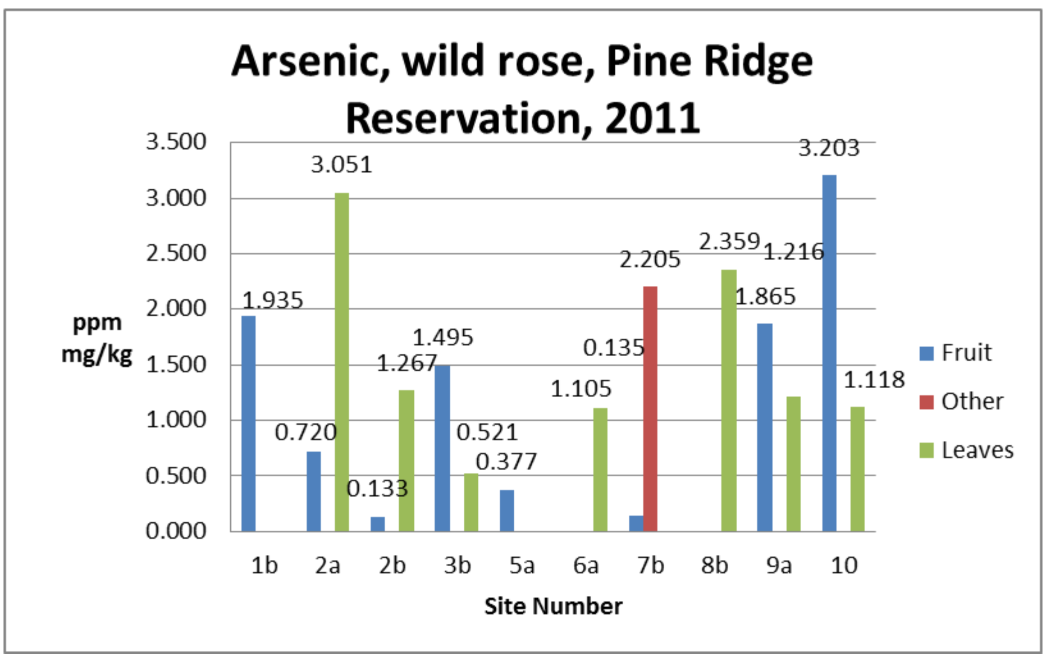

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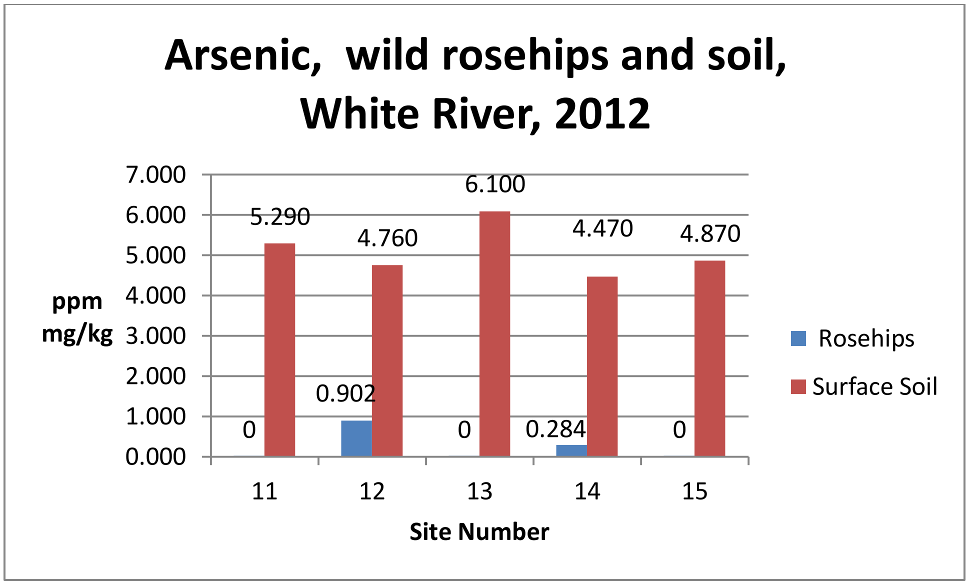

Arsenic, wild rosehips and soil, White River, 2012
ppm mg/kg
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0
5.290
0.902
4.760
0
6.100
0.284
4.470
0
4.870
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure D-7.

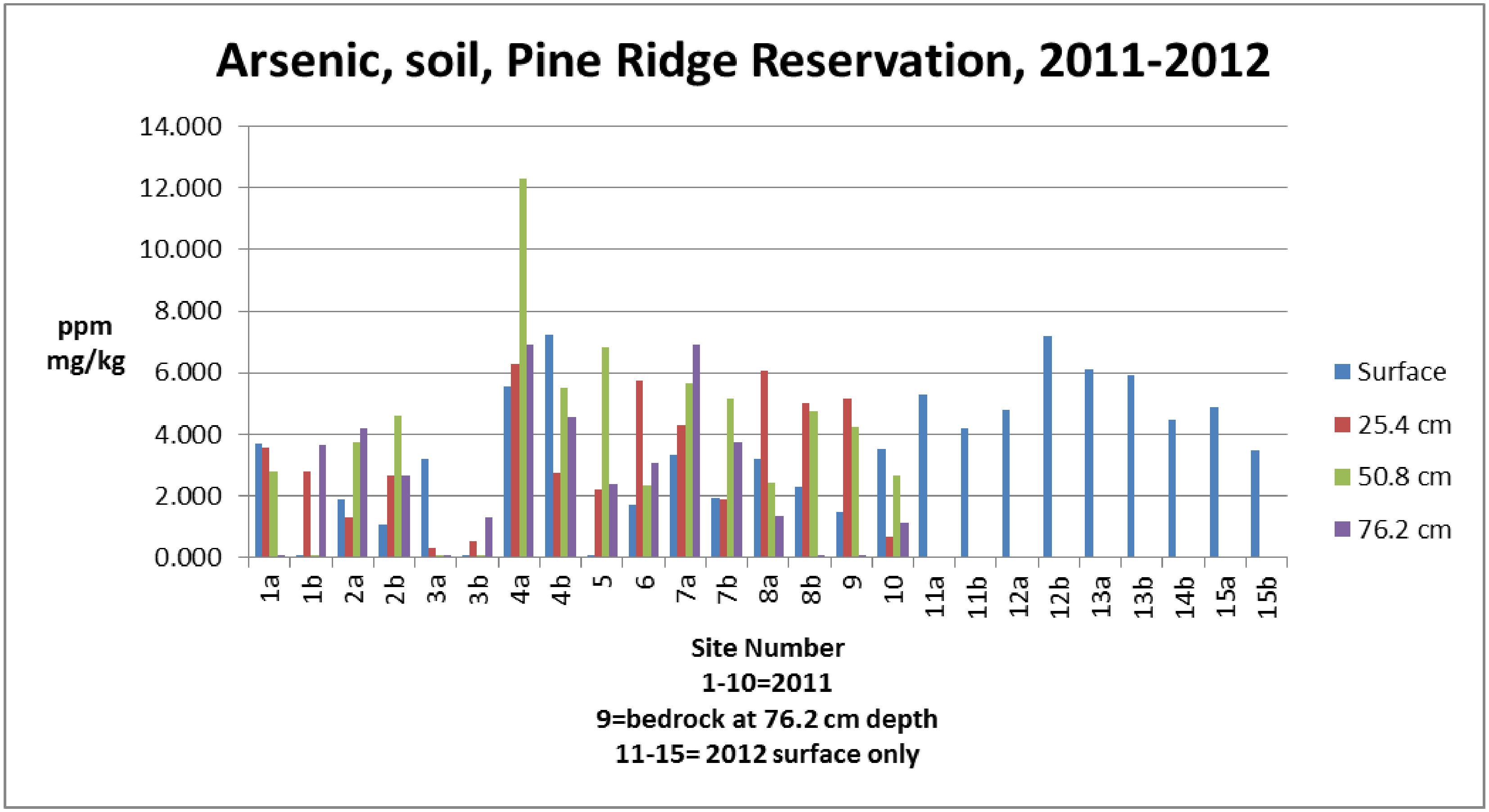

Arsenic, soil, Pine Ridge Reservation, 2011-2012
ppm
mg/kg
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Surface
25.4 cm
50.8 cm
76.2 cm
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15= 2012 surface only

Figure D-8.

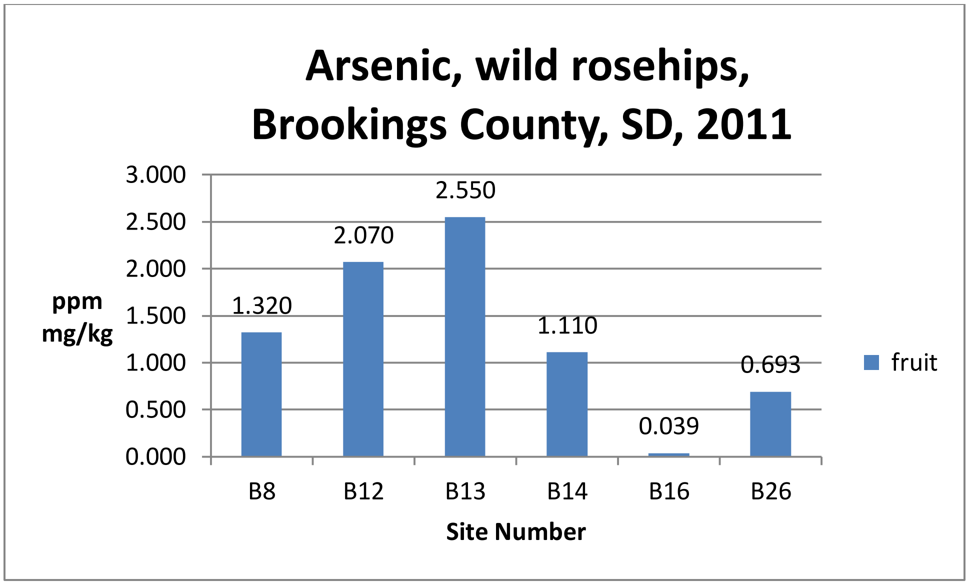

Arsenic, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
3.000
2.500
2.000
1.500
1.000
0.500
0.000
1.320
2.070
2.550
1.110
0.039
0.693
fruit
B8
B12
B13
B14
B16
B26
Site Number

Figure D-9.

APPENDIX E: BARIUM ICP-OES RESULTS

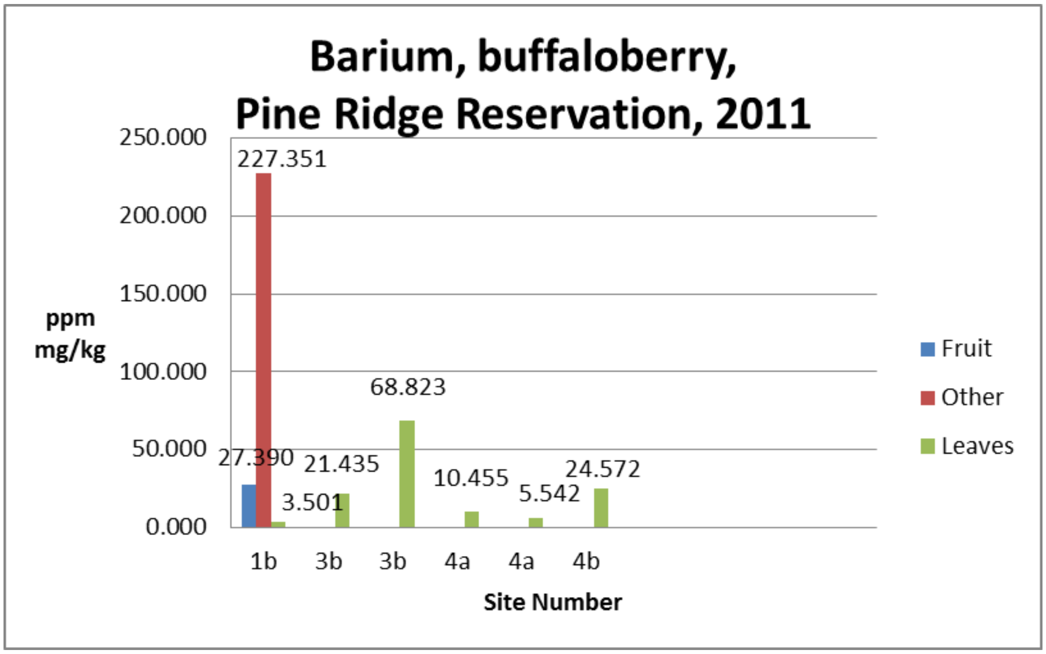


Figure E-1.

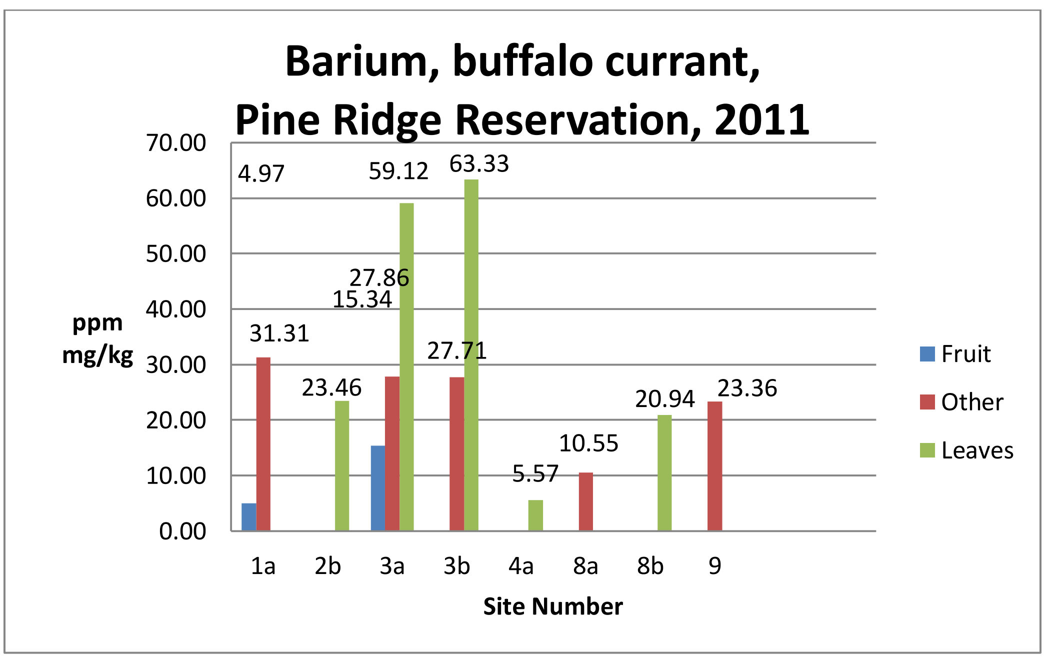


Figure E-2.

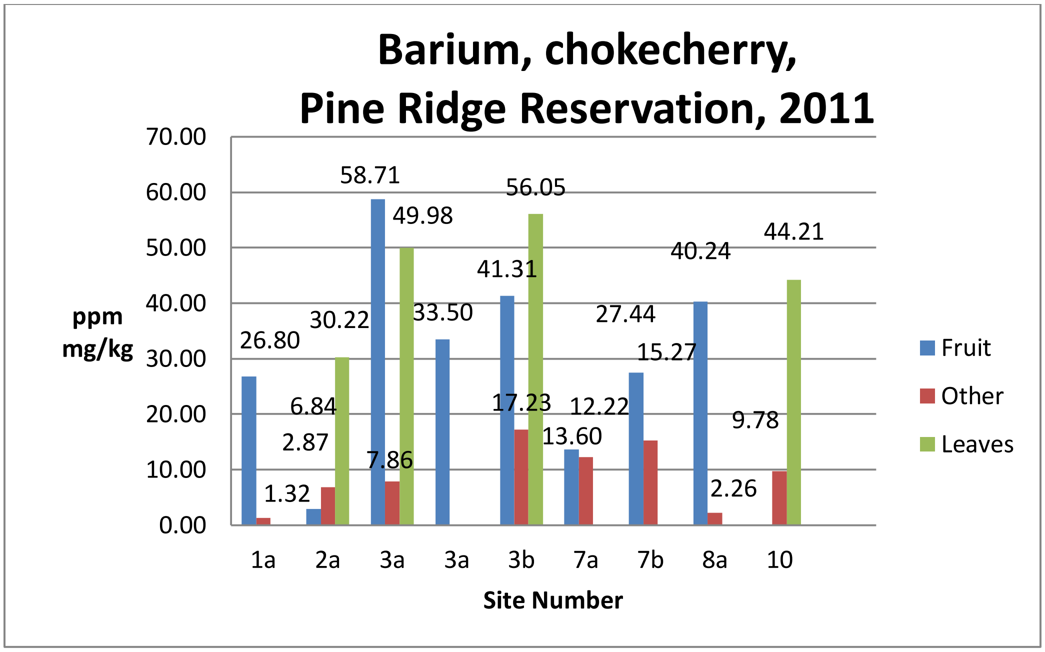


Figure E-3.

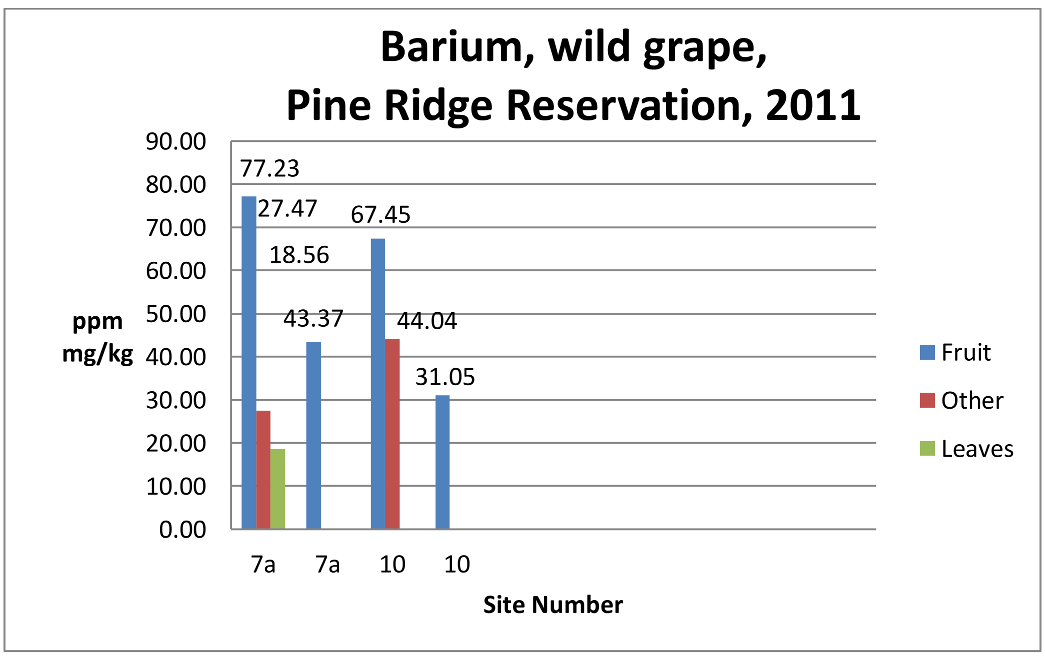


Figure E-4.

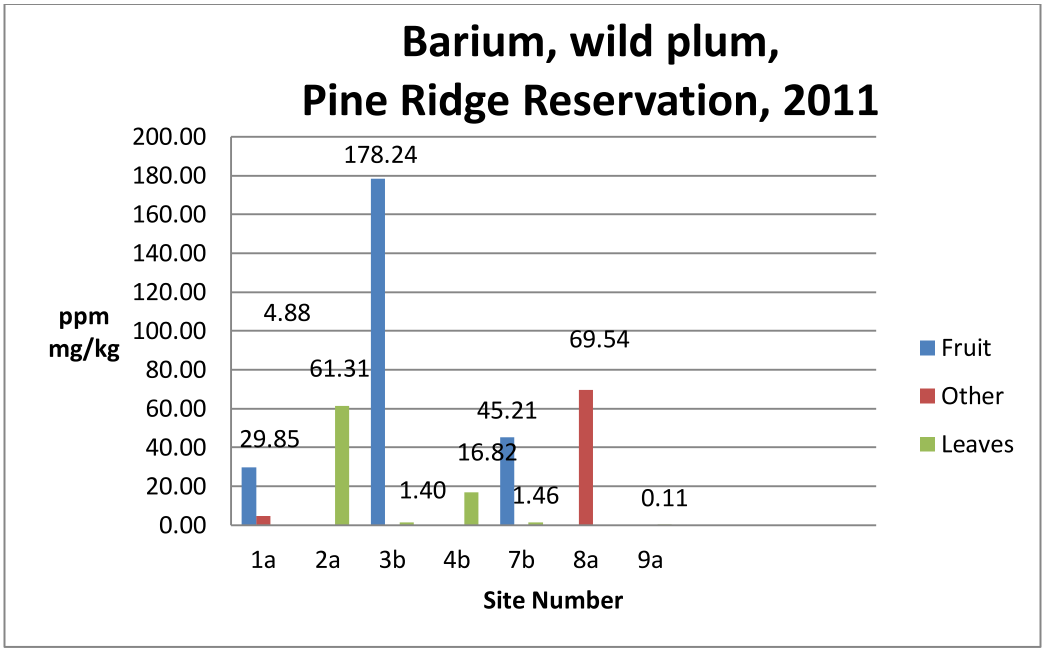

Barium, wild plum,
Pine Ridge Reservation, 2011
ppm
mg/kg
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
178.24
4.88
69.54
61.31
45.21
29.85
16.82
1.40
1.46
0.11
1a
2a
3b
4b
7b
8a
9a
Site Number
Fruit
Other
Leaves

Figure E-5.

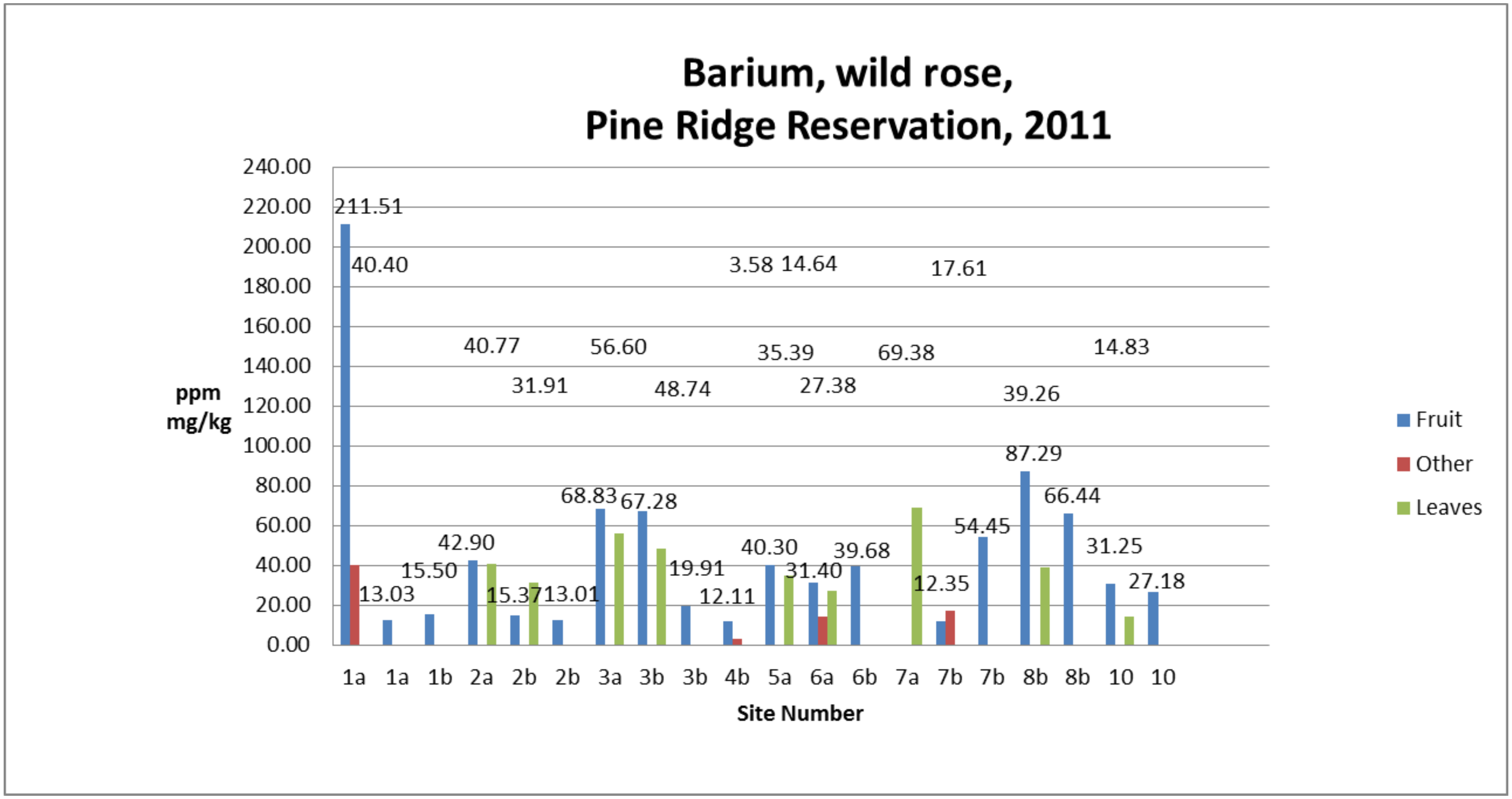

Barium, wild rose,
Pine Ridge Reservation, 2011
ppm mg/kg
Site Number
Fruit
Other
Leaves
240.00
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1a 1a 1b 2a 2b 2b 3a 3b 3b 4b 5a 6a 6b 7a 7b 7b 8b 8b 10 10
211.51
40.40
13.03
15.50
42.90
40.77
15.37
31.91
13.01
68.83
56.60
67.28
48.74
19.91
12.11
3.58
40.30
35.39
31.40
14.64
27.38
39.68
69.38
12.35
17.61
54.45
87.29
39.26
66.44
31.25
14.83
27.18

Figure E-6.

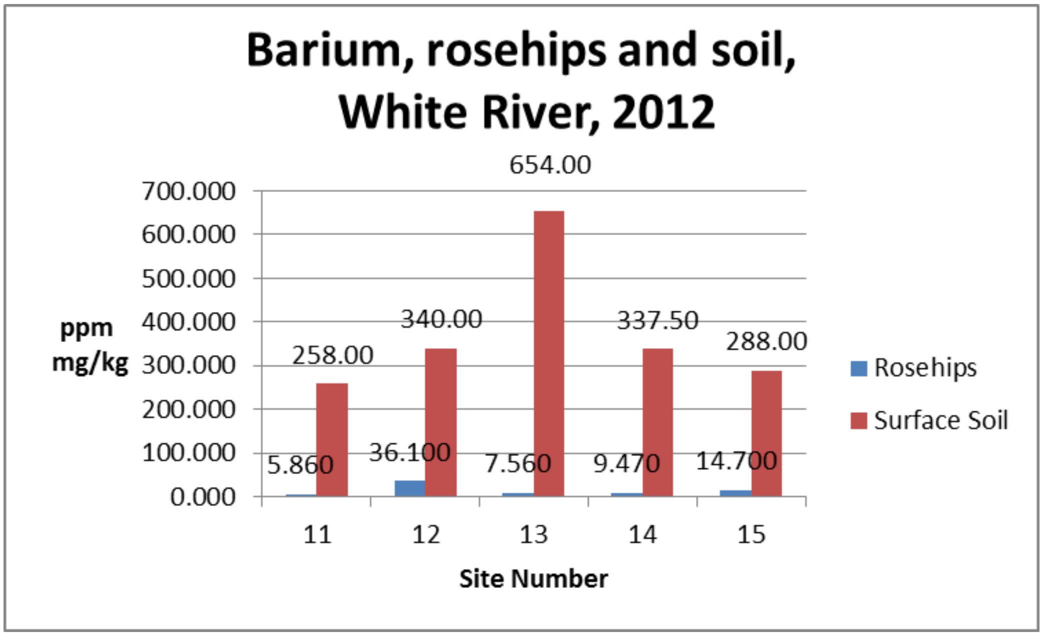
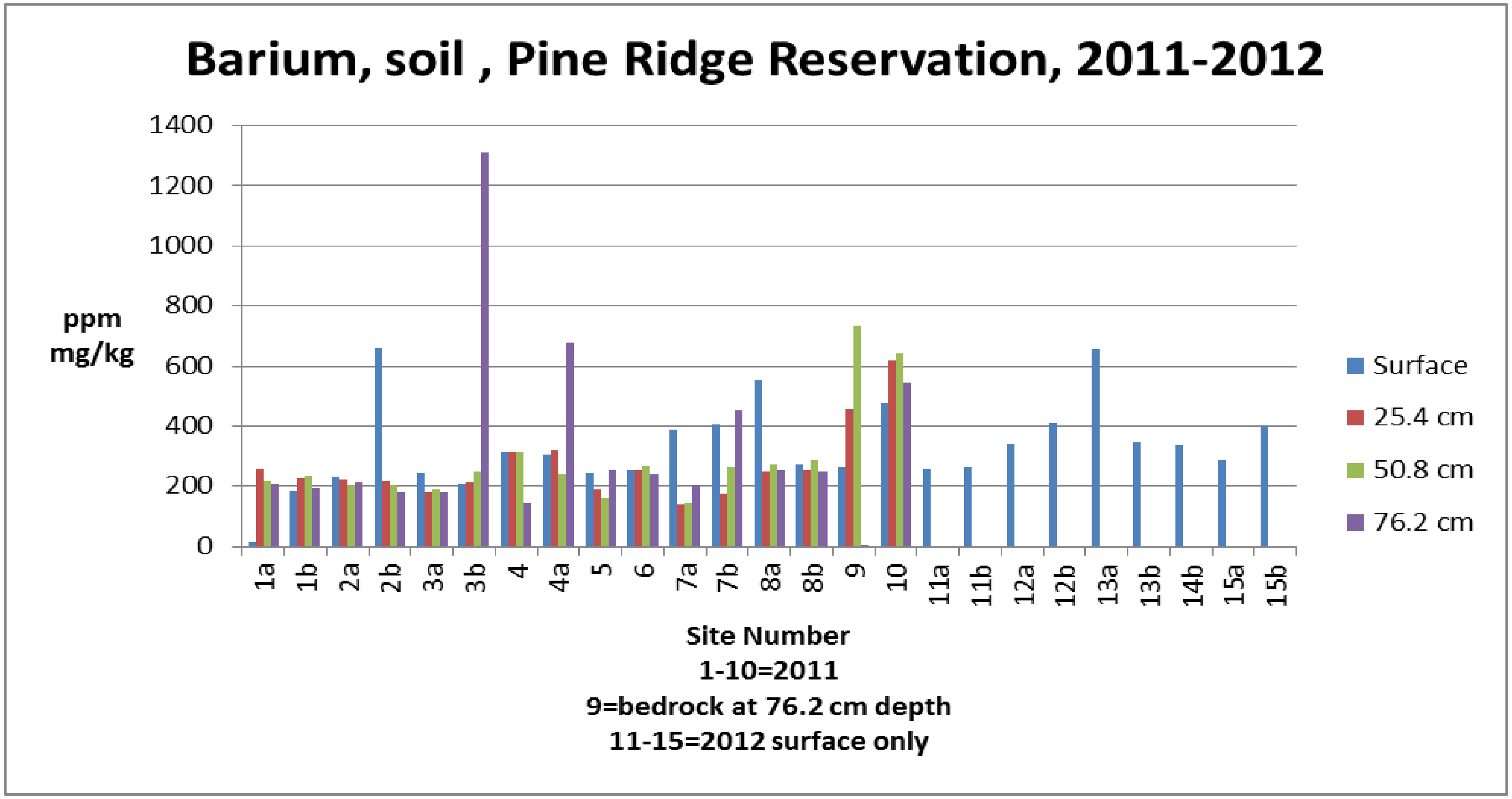

Barium, rosehips and soil, White River, 2012
654.00
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0.000
ppm mg/kg
340.00
337.50
288.00
258.00
5.860
36.100
7.560
9.470
14.700
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure E-7.



Barium, soil , Pine Ridge Reservation, 2011-2012
ppm
mg/kg
1400
1200
1000
800
600
400
200
0
1a
1b
2a
2b
3a
3b
4
4a
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15=2012 surface only
Surface
25.4 cm
50.8 cm
76.2 cm

Figure E-8.

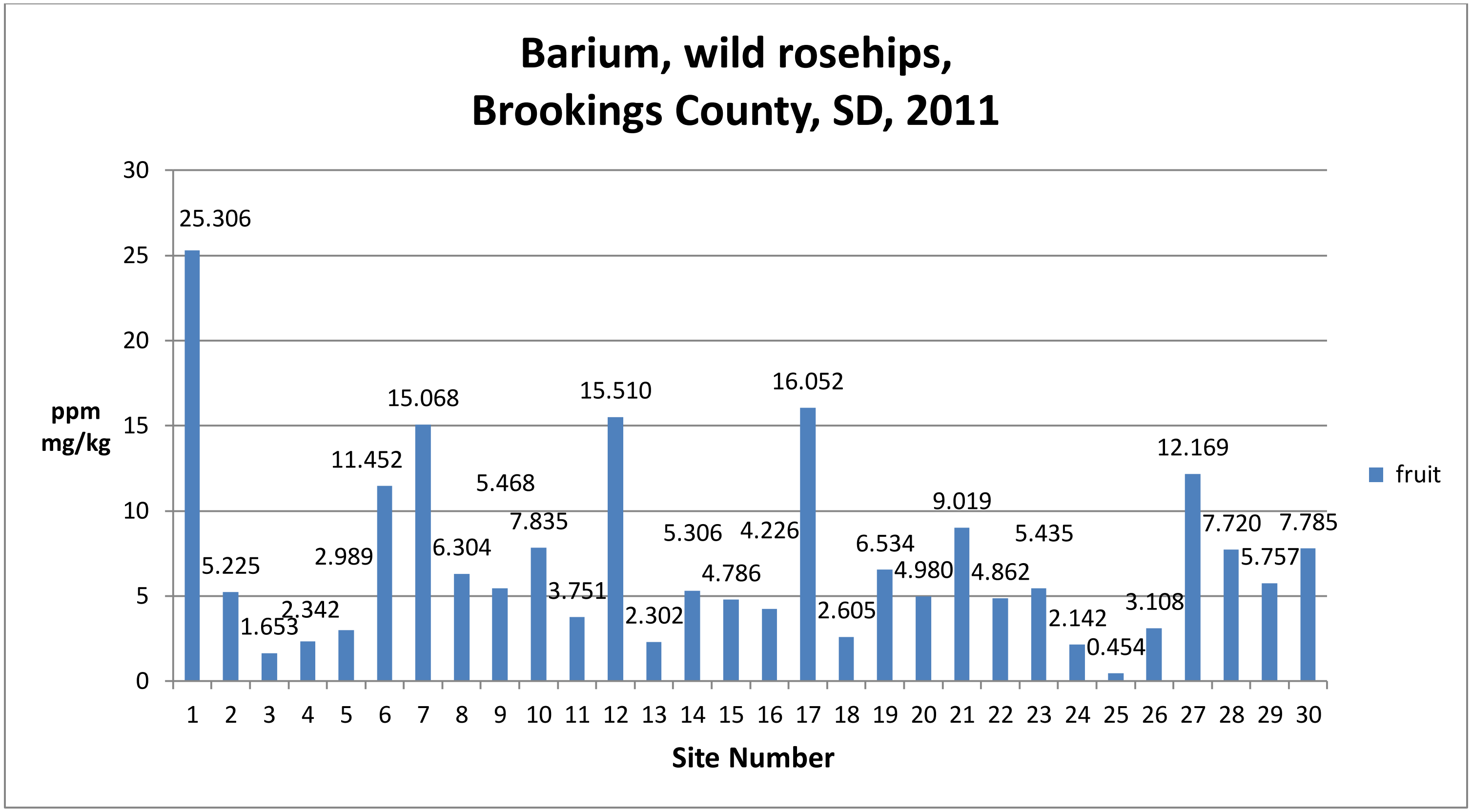

Barium, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
30
25
20
15
10
5
0
25.306
5.225
1.653
2.342
2.989
11.452
15.068
6.304
5.468
7.835
3.751
15.510
2.302
5.306
4.786
4.226
16.052
2.605
6.534
4.980
9.019
4.862
5.435
2.142
0.454
3.108
12.169
7.720
5.757
7.785
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Site Number
fruit

Figure E-9.

APPENDIX F: LEAD ICP-OES RESULTS

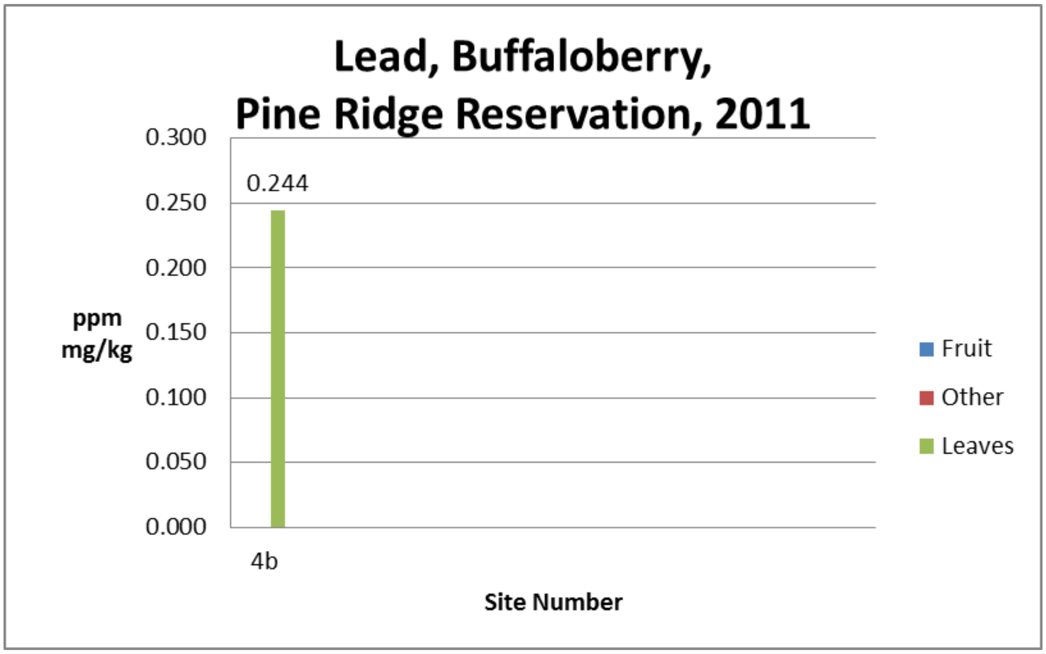


Figure F-1.

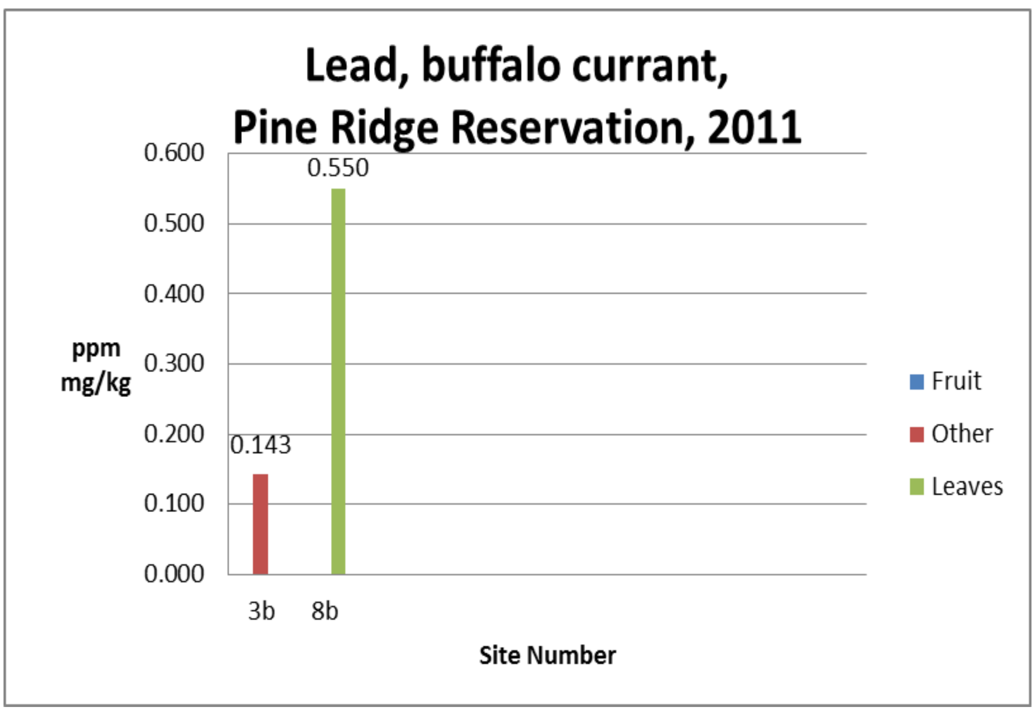


Figure F-2

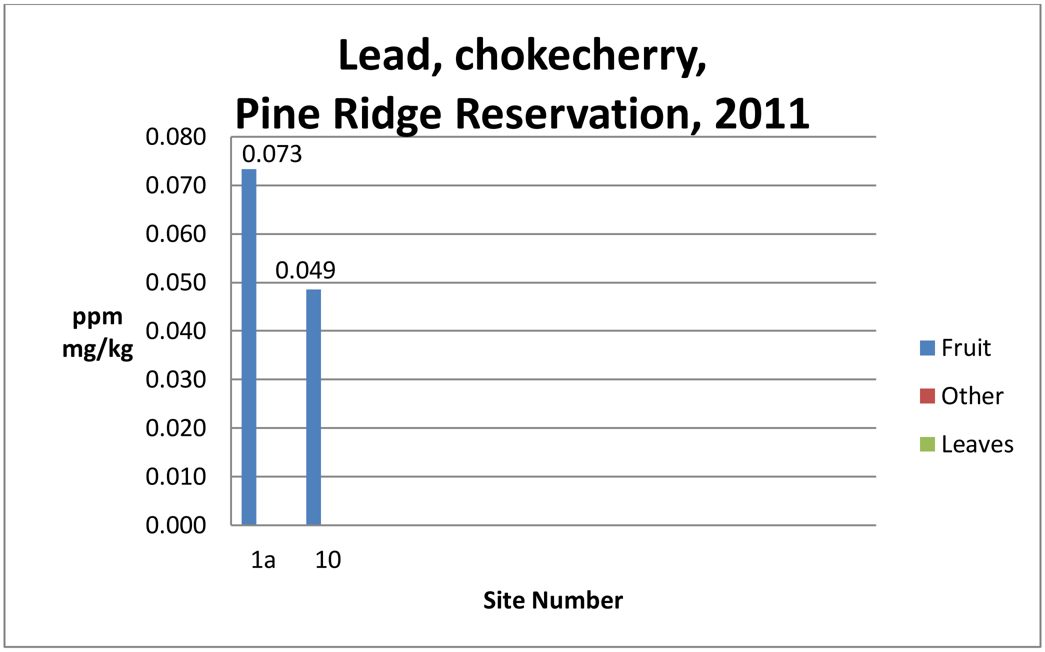


Figure F-3.

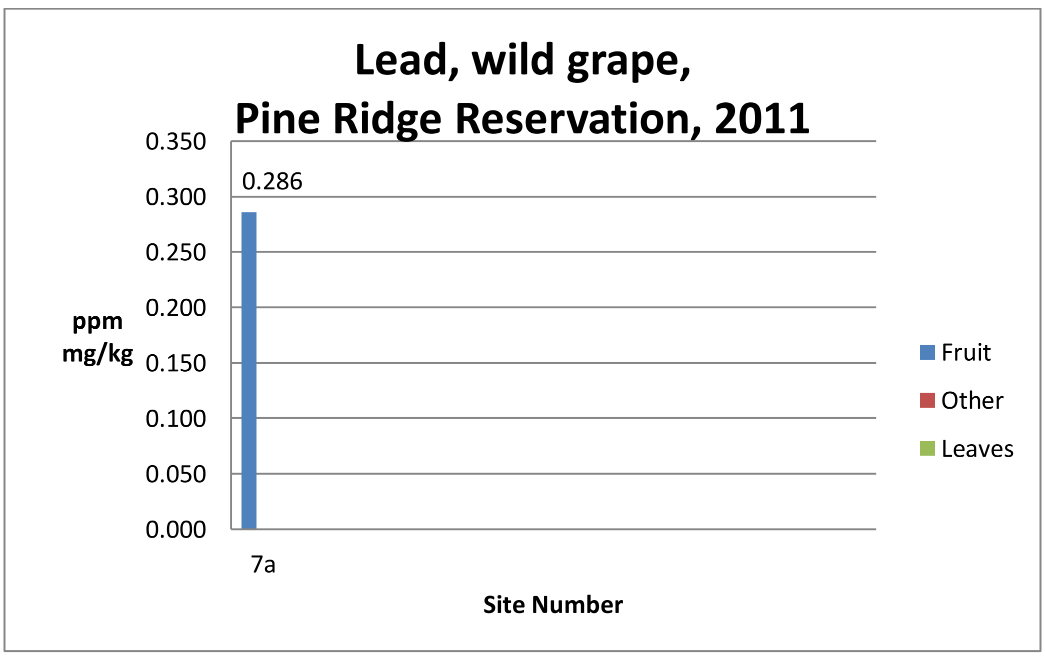


Figure F-4.

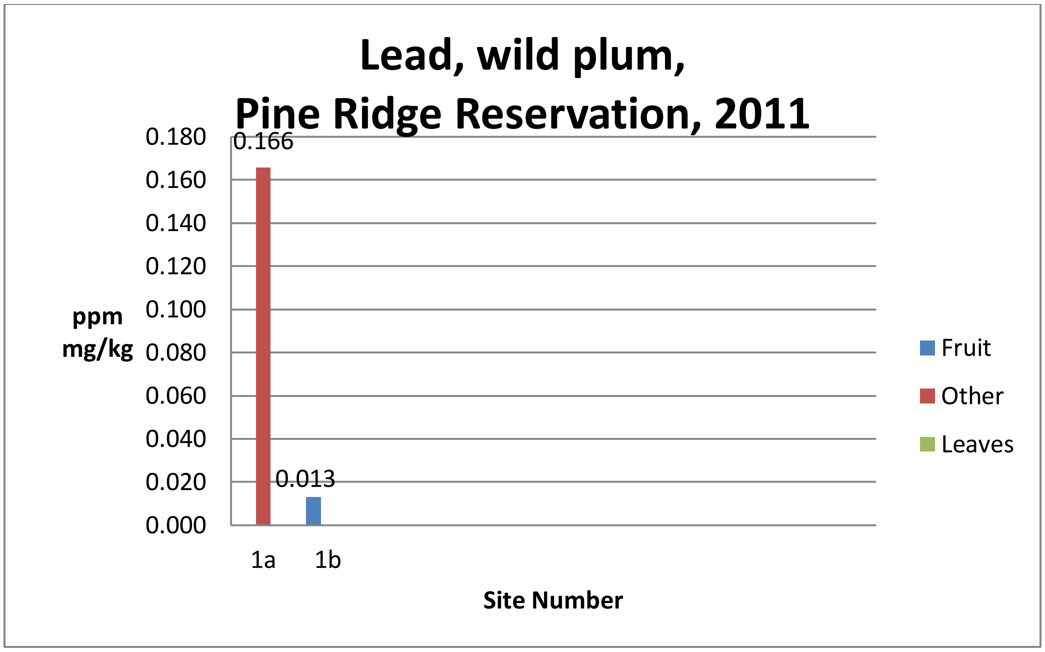


Figure F-5.

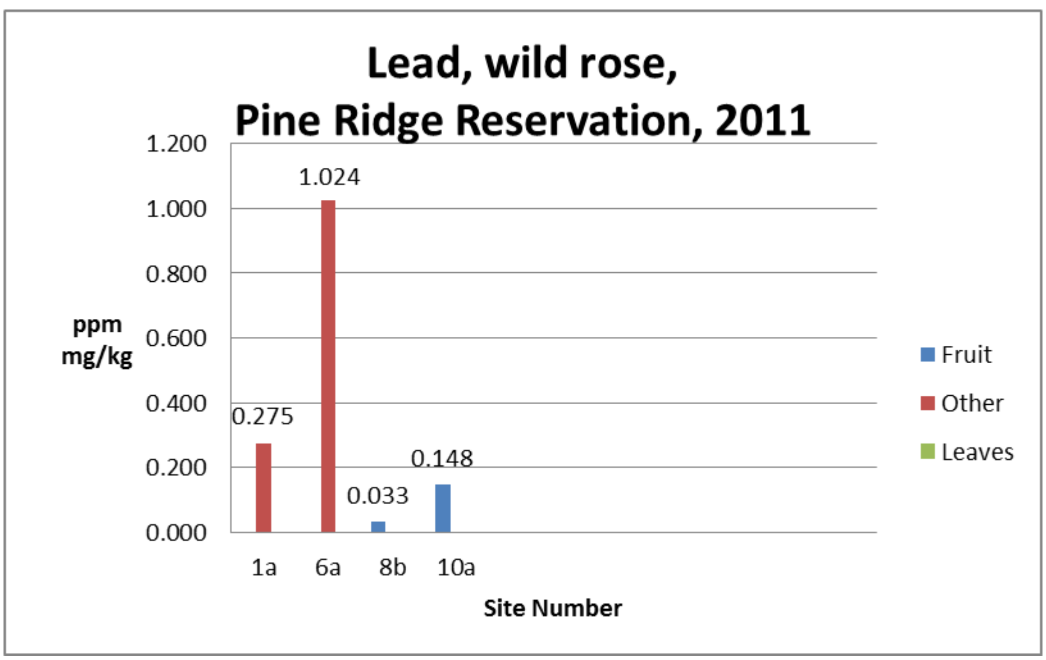


Figure F-6.

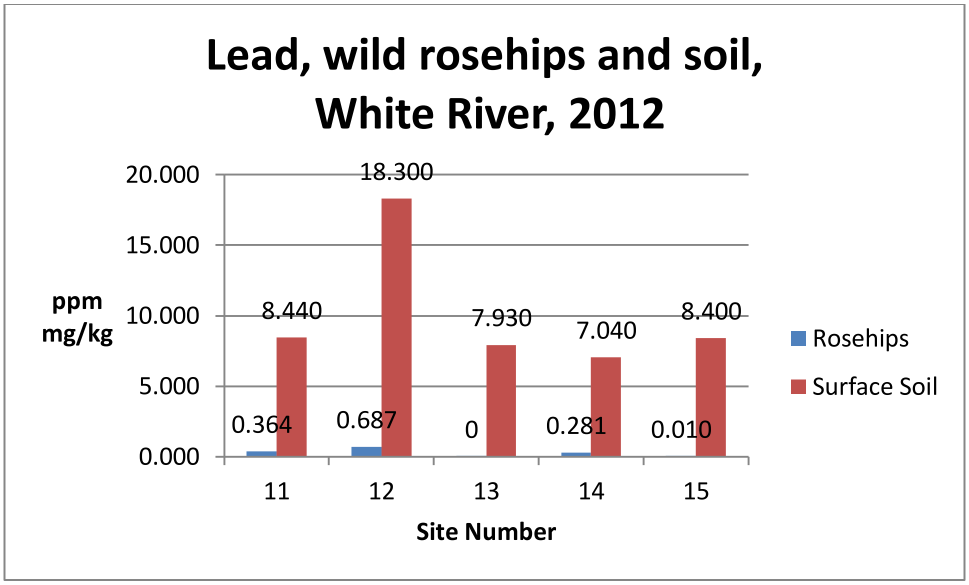

Lead, wild rosehips and soil, White River, 2012
ppm mg/kg
20.000
15.000
10.000
5.000
0.000
18.300
8.440
7.930
7.040
8.400
0.364
0.687
0
0.281
0.010
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure F-7.

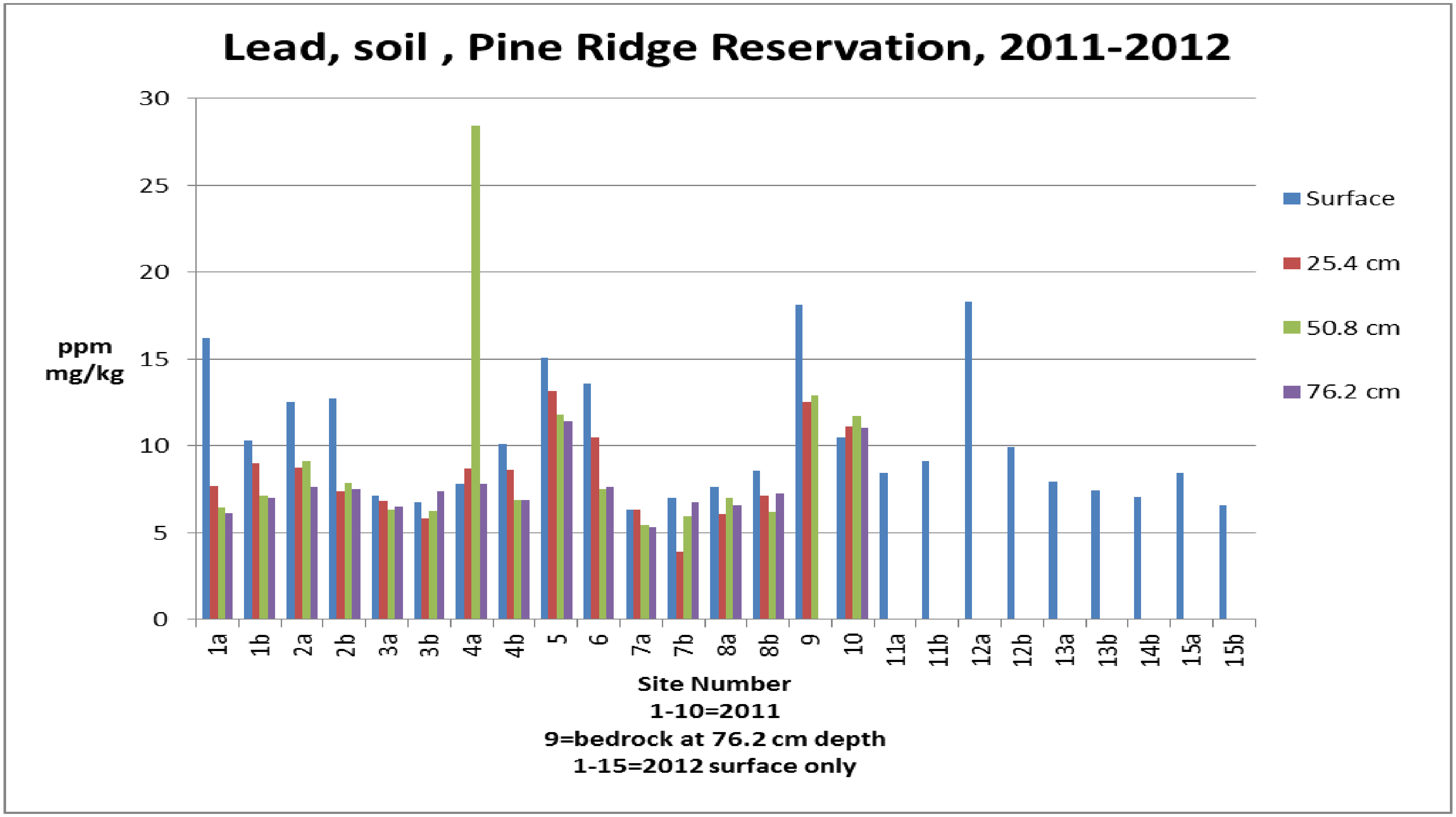

Lead, soil , Pine Ridge Reservation, 2011-2012
30
25
20
15
10
5
0
ppm
mg/kg
Surface
25.4 cm
50.8 cm
76.2 cm
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
1-15=2012 surface only

Figure F-8.

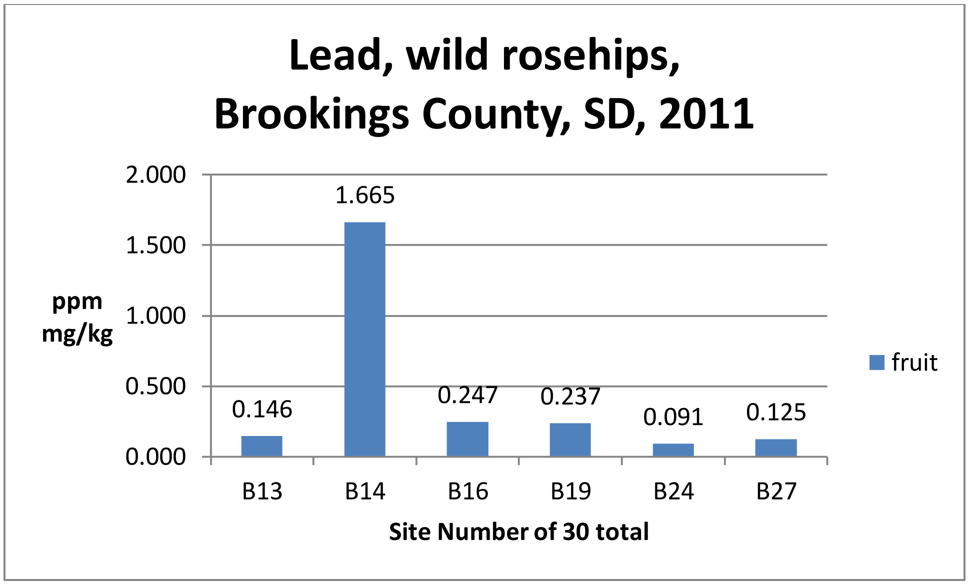

Lead, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
2.000
1.500
1.000
0.500
0.000
1.665
0.146
0.247
0.237
0.091
0.125
B13
B14
B16
B19
B24
B27
Site Number of 30 total
fruit

Figure F-9.

APPENDIX G: SELENIUM ICP-OES RESULTS

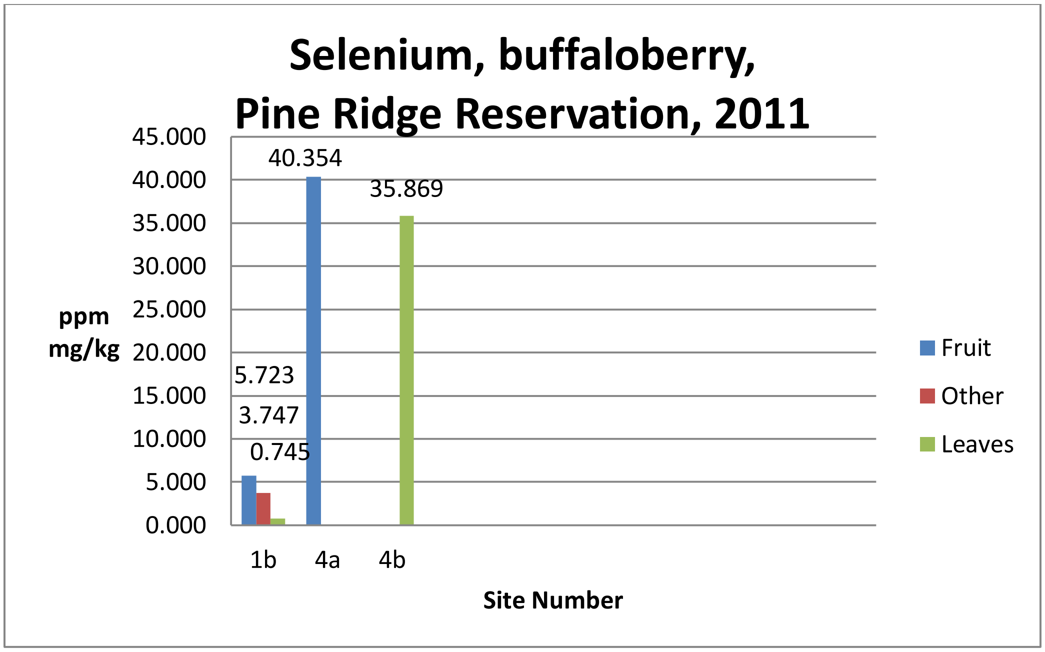


Figure G-1.

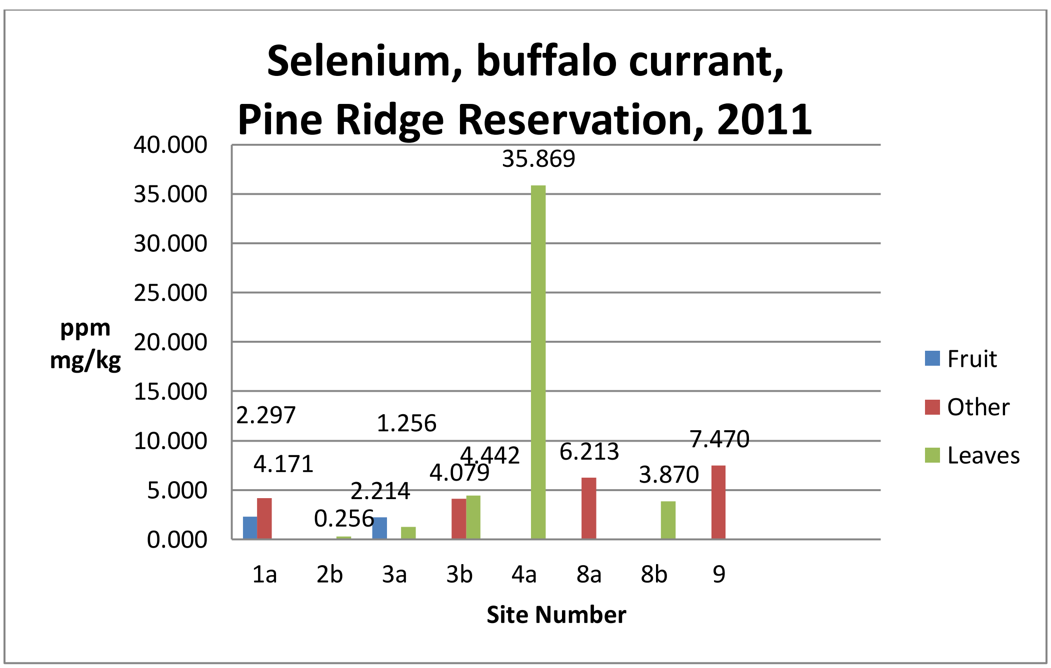


Figure G-2.

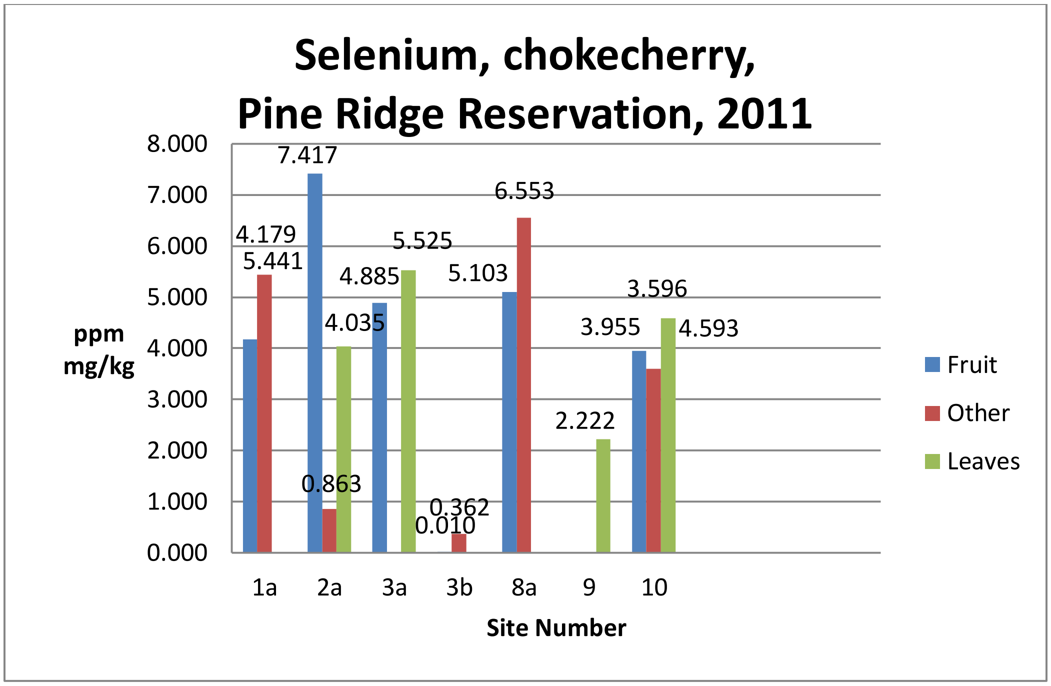


Figure G-3.

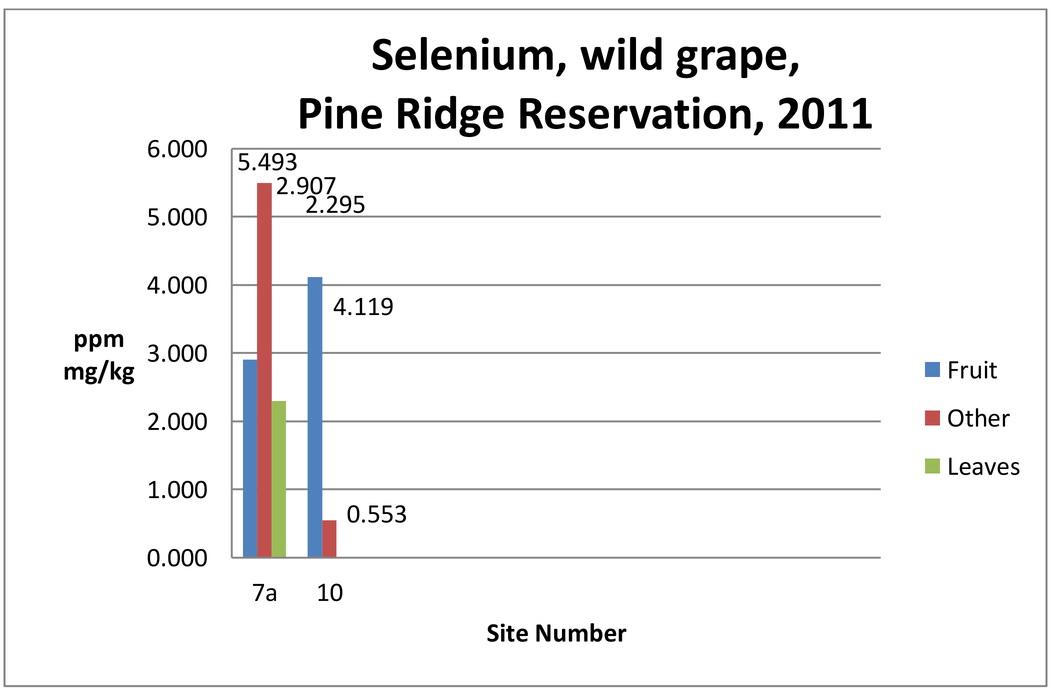


Figure G-4.

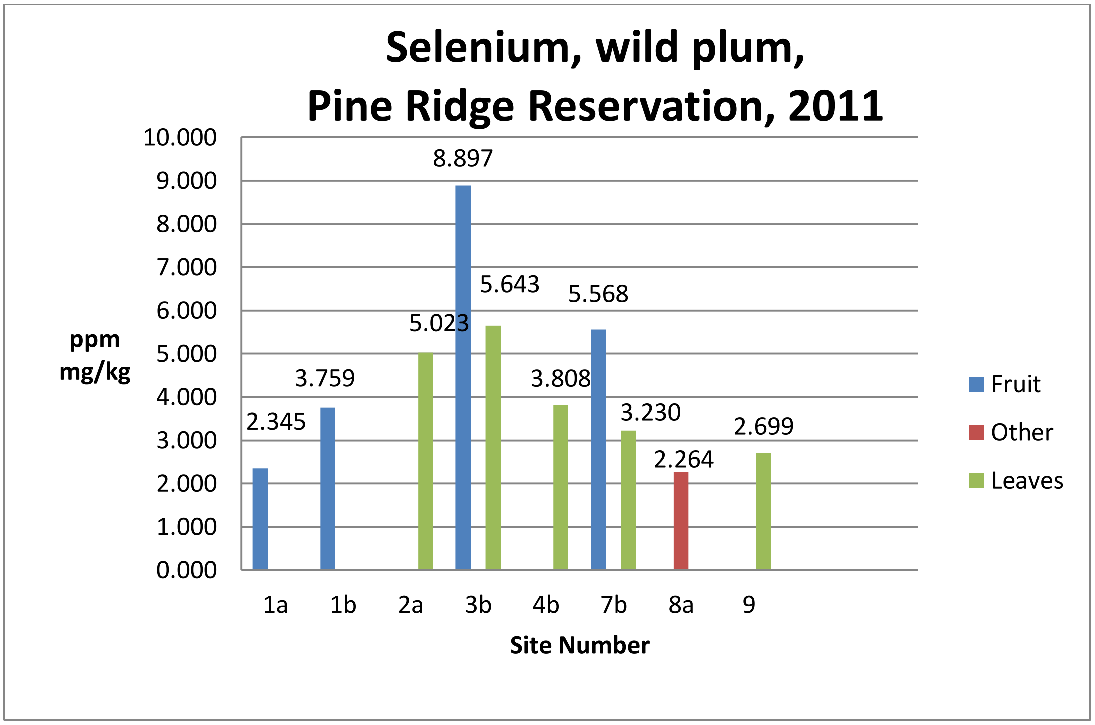

Selenium, wild plum,
Pine Ridge Reservation, 2011
ppm
mg/kg
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
2.345
3.759
5.023
8.897
5.643
3.808
5.568
3.230
2.264
2.699
1a
1b
2a
3b
4b
7b
8a
9
Site Number
Fruit
Other
Leaves

Figure G-5.

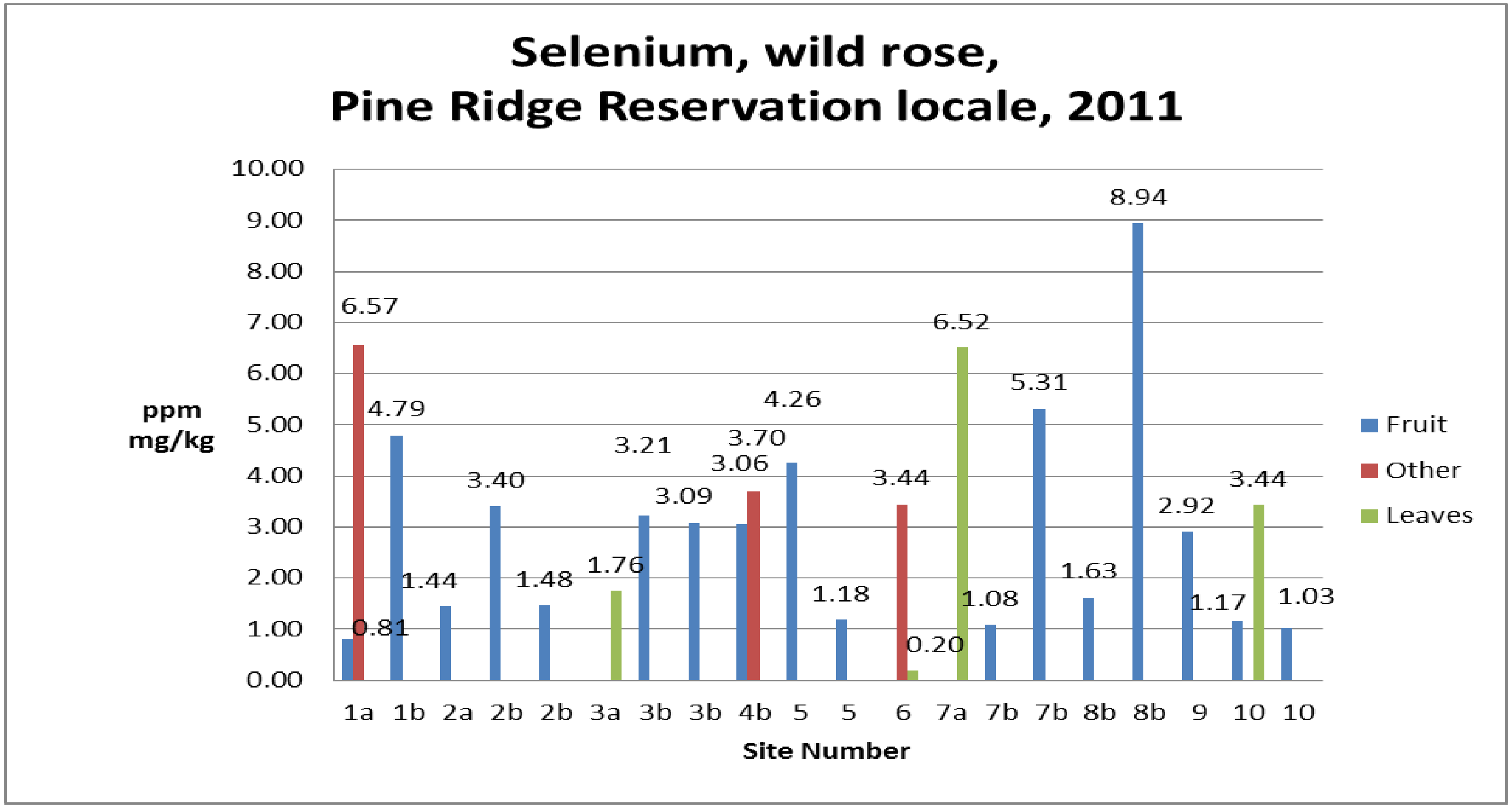

Selenium, wild rose,
Pine Ridge Reservation locale, 2011
ppm
mg/kg
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
6.57
4.79
0.81
1.44
3.40
1.48
1.76
3.21
3.09
3.70
3.06
4.26
1.18
3.44
0.20
6.52
1.08
5.31
1.63
8.94
2.92
1.17
3.44
1.03
1a 1b 2a 2b 2b 3a 3b 3b 4b 5 5 6 7a 7b 7b 8b 8b 9 10 10
Site Number
Fruit
Other
Leaves

Figure G-6.

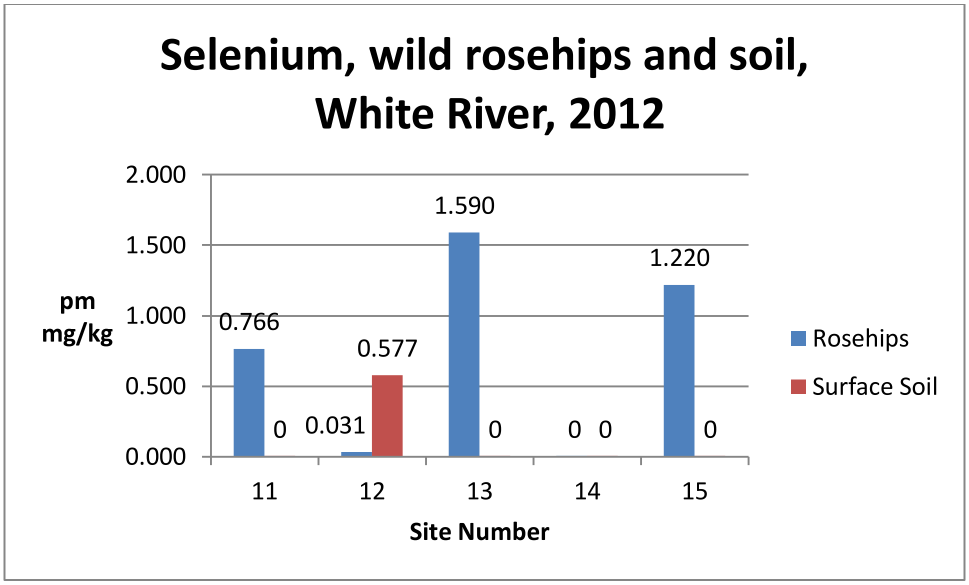

Selenium, wild rosehips and soil,
White River, 2012
pm
mg/kg
2.000
1.500
1.000
0.500
0.000
0.766
0
0.031
0.577
1.590
0
0 0
1.220
0
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure G-7.

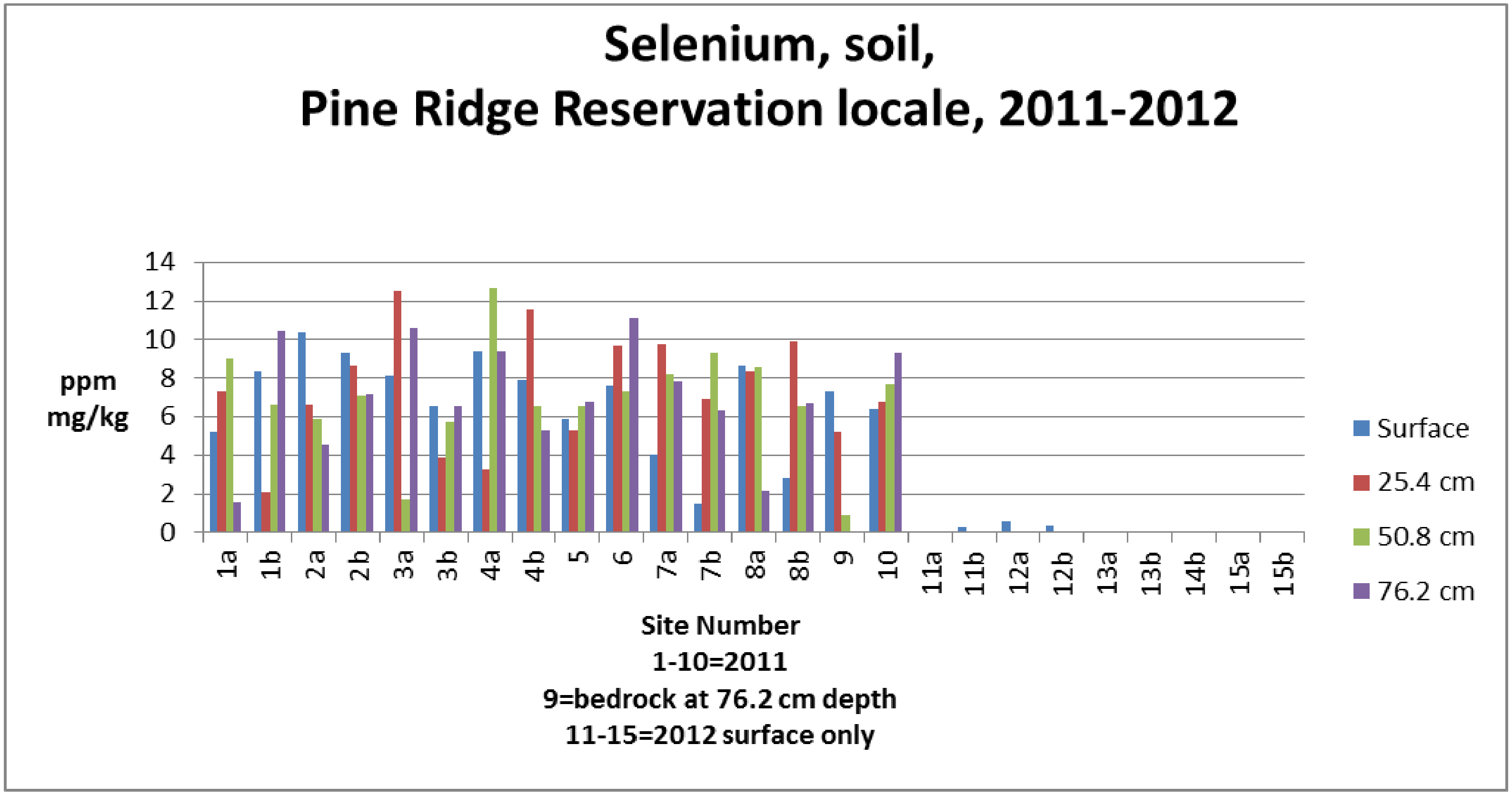

Selenium, soil,
Pine Ridge Reservation locale, 2011-2012
ppm
mg/kg
14
12
10
8
6
4
2
0
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Surface
25.4 cm
50.8 cm
76.2 cm
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15=2012 surface only

Figure G-8.

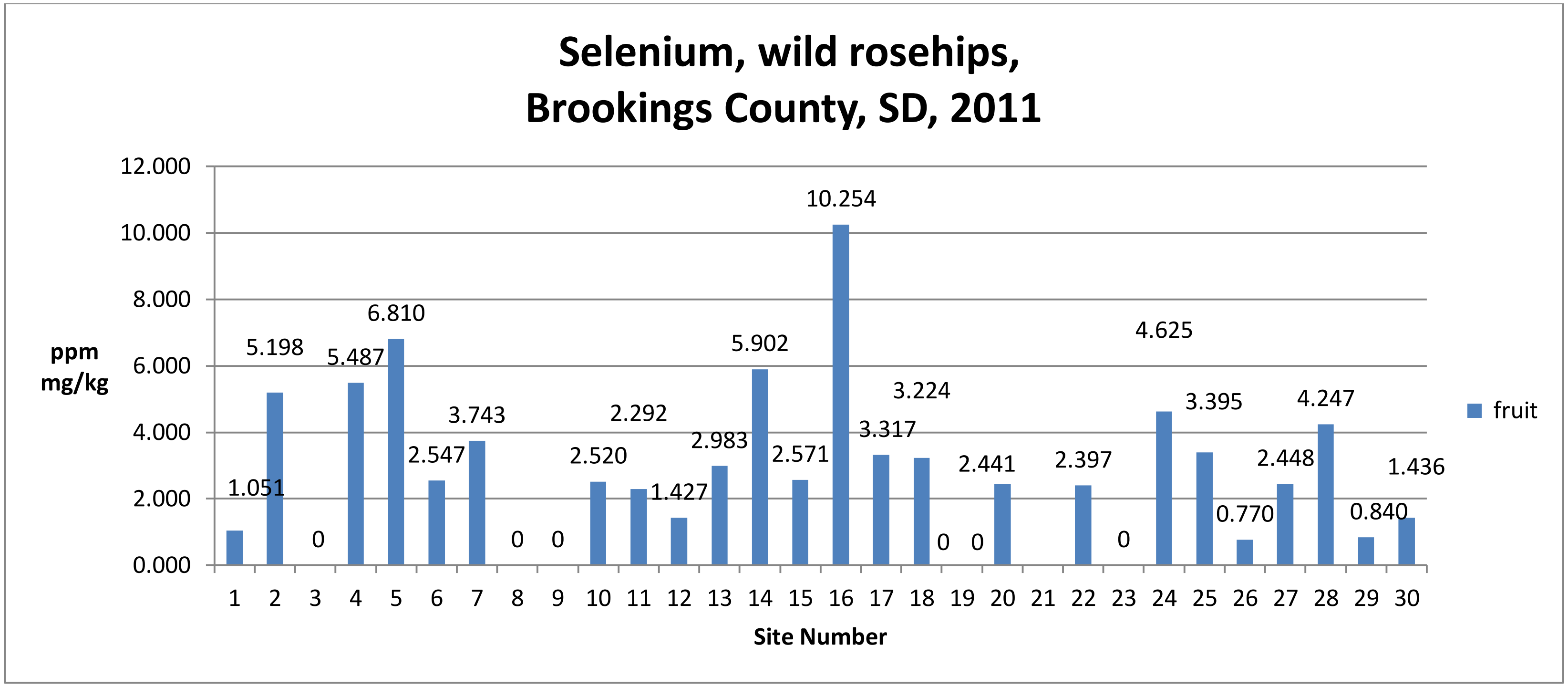

Selenium, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
12.000
10.000
8.000
6.000
4.000
2.000
0.000
1.051
5.198
0
5.487
6.810
2.547
3.743
0
0
2.520
2.292
1.427
2.983
5.902
2.571
10.254
3.317
3.224
0
0
2.441
2.397
0
4.625
3.395
0.770
2.448
4.247
0.840
1.436
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Site Number
fruit

Figure G-9.

APPENDIX H: URANIUM ICP-OES RESULTS

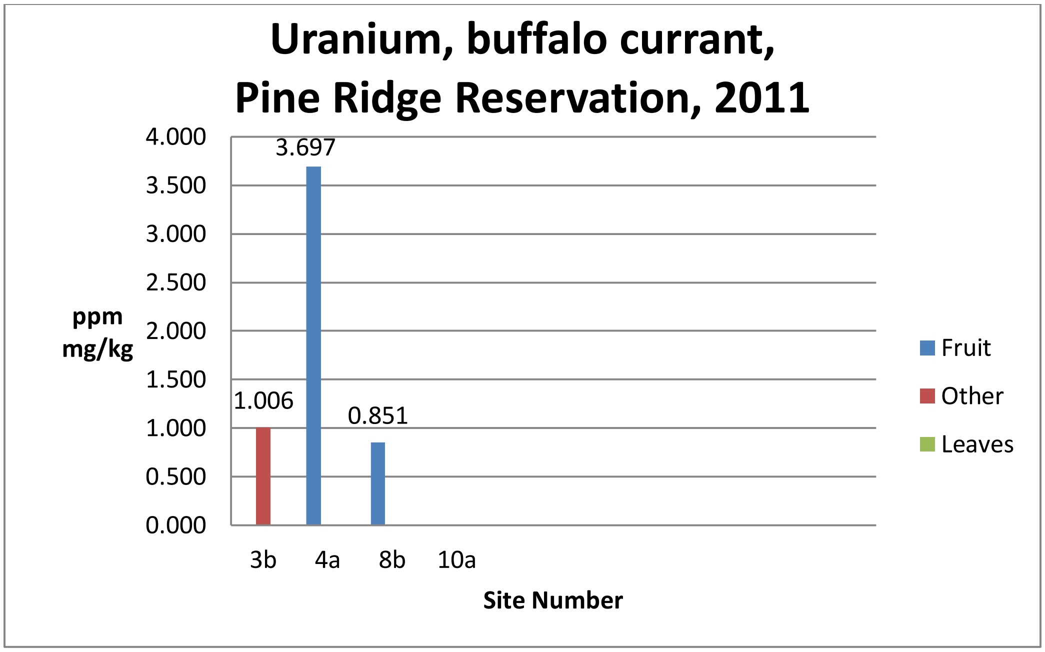


Figure H-1.

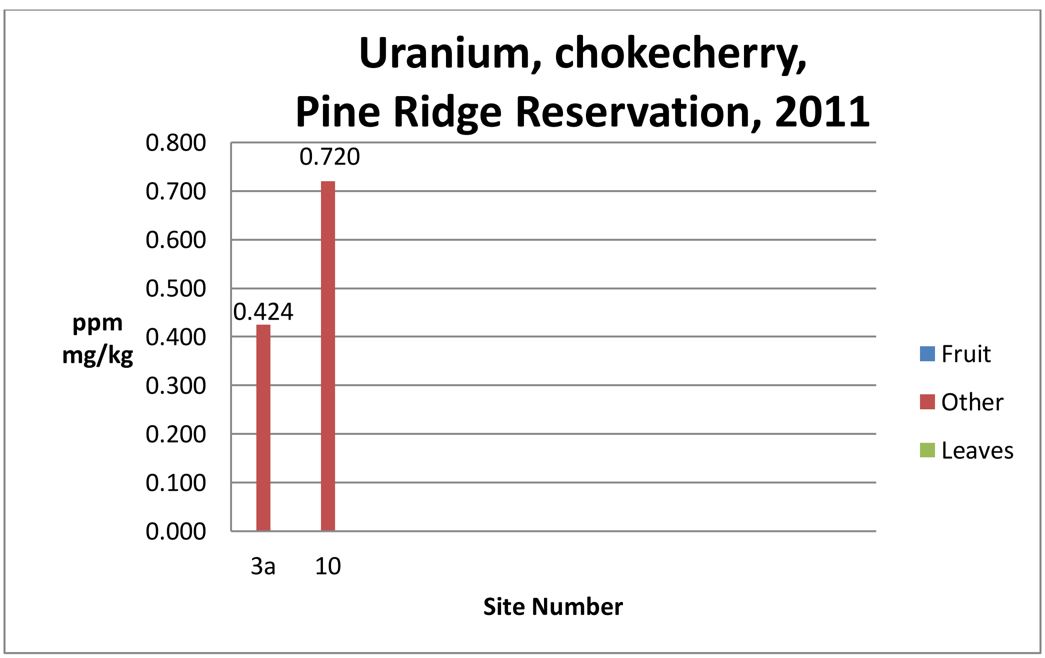


Figure H-2.

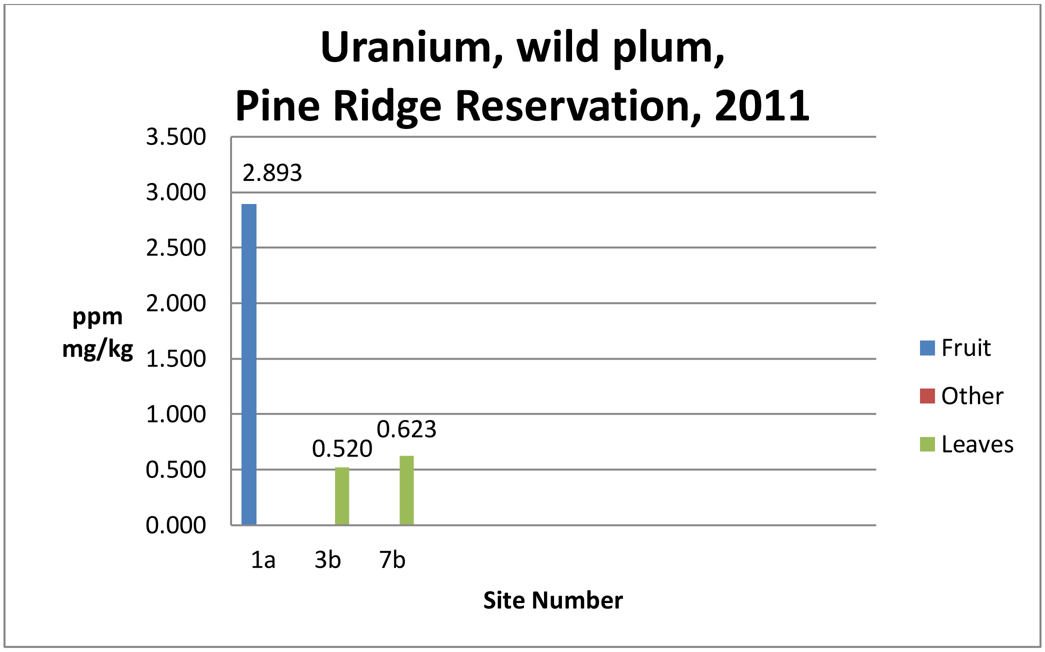


Figure H-3.

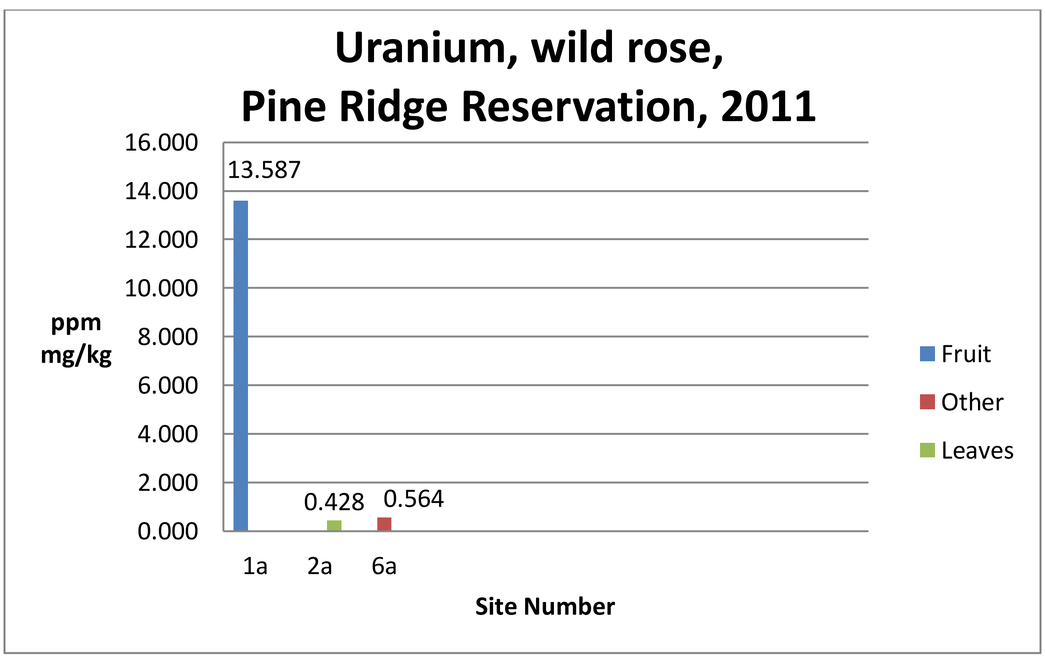


Figure H-4.

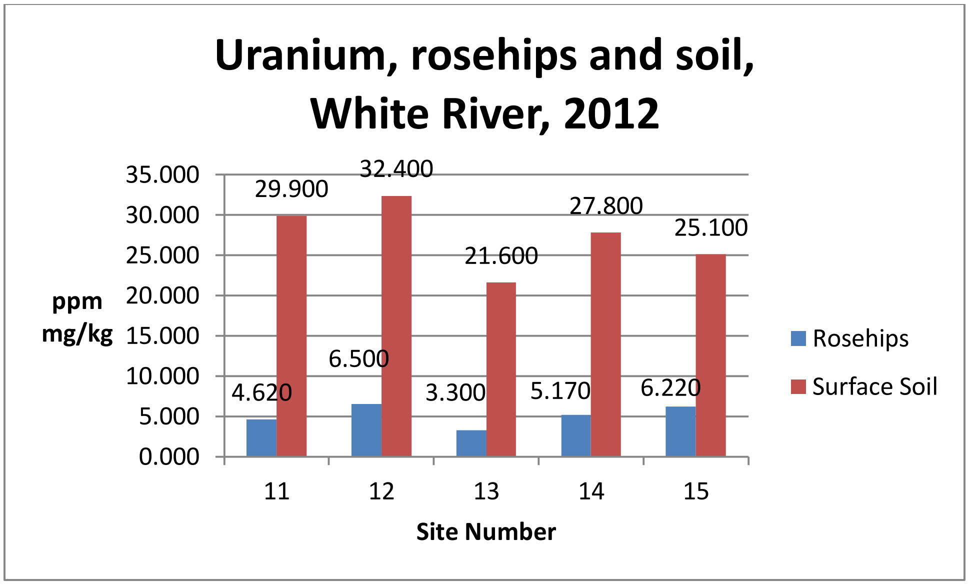

Uranium, rosehips and soil,
White River, 2012
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
ppm
mg/kg
29.900
32.400
21.600
27.800
25.100
4.620
6.500
3.300
5.170
6.220
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure H-5.

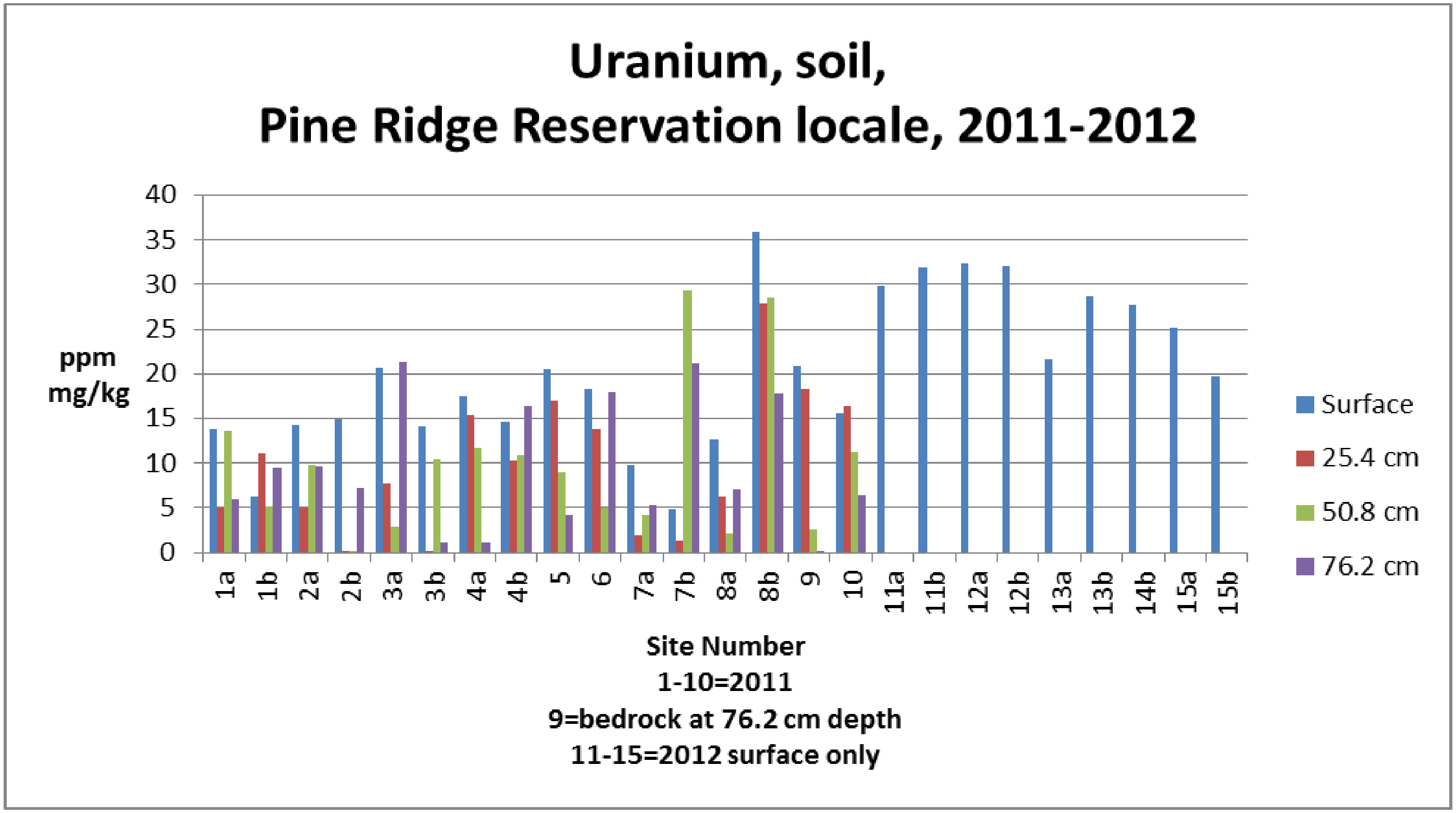

Uranium, soil,
Pine Ridge Reservation locale, 2011-2012
ppm
mg/kg
40
35
30
25
20
15
10
5
0
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Surface
25.4 cm
50.8 cm
76.2 cm
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15=2012 surface only

Figure H-6.

APPENDIX I: COMPREHENSIVE ICP-OES RESULTS BY SITE

Table I-1. All plant samples, PRR locale, Sites 1-10, 2011.
Key: Blue highlights indicate high score in the range, BC=buffalo currant, CC=chokecherry, PL=plum, RE=rose, BB=buffaloberry, and GR=grape.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
1a	40	0.000	4.968	0.000	2.297	0.000	BC fruit	PRR	2011
1a	41	0.000	31.314	0.000	4.171	0.000	BC other	PRR	2011
1a	42	0.000	28.803	0.074	4.179	0.000	CC fruit	PRR	2011
1a	43	1.091	1.320	0.000	5.441	0.000	CC other	PRR	2011
1a	44	0.000	29.852	0.000	2.345	2.893	PL fruit	PRR	2011
1a	45	0.744	4.878	0.166	0.000	0.000	PL other	PRR	2011
1a	270	0.000	211.506	0.000	0.000	13.587	RE fruit	PRR	2011
1a	51	0.000	13.029	0.000	0.805	0.000	RE fruit	PRR	2011
1a	46	0.000	40.400	0.275	6.572	0.000	RE other	PRR	2011
1b	49	0.683	27.390	0.000	5.723	0.000	BB fruit	PRR	2011
1b	170	0.000	227.351	0.000	3.747	0.000	BB other	PRR	2011
1b	50	0.000	5.501	0.000	0.445	0.453	BB leaf	PRR	2011
1b	54	1.033	23.450	0.013	3.759	0.000	PL fruit	PRR	2011
1b	53	1.935	15.499	0.000	4.794	0.000	RE fruit	PRR	2011
2a	55	0.000	2.873	0.000	7.417	0.000	CC fruit	PRR	2011
2a	56	0.000	6.841	0.000	0.863	0.863	CC other	PRR	2011
2a	57	0.000	30.225	0.000	4.035	0.000	CC leaf	PRR	2011
2a	58	0.124	61.308	0.000	5.023	0.000	PL leaf	PRR	2011
2a	63	0.720	42.900	0.000	1.438	0.000	RE fruit	PRR	2011
2a	59	3.051	40.766	0.000	0.000	0.428	RE leaf	PRR	2011
2b	60	0.000	23.461	0.000	0.256	0.000	BC leaf	PRR	2011
2b	61	0.000	15.368	0.000	3.403	0.000	RE fruit	PRR	2011
2b	64	0.133	13.013	0.000	1.477	0.000	RE fruit	PRR	2011
2b	62	1.267	31.909	0.000	0.000	0.000	RE leaf	PRR	2011

Table I-1, continued.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
3a	65	2.577	15.341	0.000	2.214	0.000	BC fruit	PRR	2011
3a	66	0.000	27.863	0.000	0.000	0.000	BC other	PRR	2011
3a	67	1.694	59.116	0.000	1.256	0.000	BC leaf	PRR	2011
3a	68	0.275	58.710	0.000	0.000	0.000	CC fruit	PRR	2011
3a	90	1.933	33.503	0.000	4.885	0.000	CC fruit	PRR	2011
3a	70	0.363	7.860	0.000	0.000	0.424	CC other	PRR	2011
3a	71	0.000	49.979	0.000	5.525	0.000	CC leaf	PRR	2011
3a	86	0.000	68.823	0.000	0.000	0.000	RE fruit	PRR	2011
3a	72	0.000	56.600	0.000	1.755	0.000	RE leaf	PRR	2011
3b	73	0.000	21.435	0.000	0.000	0.000	BB leaf	PRR	2011
3b	88	0.000	68.823	0.000	0.000	0.000	BB leaf	PRR	2011
3b	75	0.000	27.710	0.143	0.143	1.006	BC other	PRR	2011
3b	77	0.000	63.330	0.000	4.442	0.000	BC leaf	PRR	2011
3b	78	0.000	41.312	0.000	0.010	0.000	CC fruit	PRR	2011
3b	79	0.009	17.234	0.000	0.362	0.000	CC other	PRR	2011
3b	80	1.457	56.045	0.000	0.000	0.000	CC leaf	PRR	2011
3b	81	0.000	178.236	0.000	8.897	0.000	PL fruit	PRR	2011
3b	83	0.858	1.397	0.000	5.643	0.520	PL leaf	PRR	2011
3b	84	1.495	67.283	0.000	3.214	0.000	RE fruit	PRR	2011
3b	89	0.000	19.913	0.000	3.093	0.000	RE fruit	PRR	2011
3b	85	0.521	48.745	0.000	0.000	0.000	RE leaf	PRR	2011
4a	91	0.000	10.455	0.000	40.354	0.000	BB leaf	PRR	2011
4a	93	0.000	5.542	0.000	0.000	0.000	BB leaf	PRR	2011
4a	96	0.000	0.000	0.000	0.000	0.000	BB leaf	PRR	2011
4b	92	1.601	5.566	0.000	35.869	3.697	BC leaf	PRR	2011
4b	97	0.000	24.572	0.244	6.412	0.000	BB leaf	PRR	2011
4b	95	0.000	16.820	0.000	3.808	0.000	PL leaf	PRR	2011
4b	98	0.000	12.109	0.000	3.059	0.000	RE fruit	PRR	2011
4b	94	0.000	3.576	0.000	3.701	0.000	RE other	PRR	2011

Table I-1, continued.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
5	99	0.000	0.000	0.000	4.257	0.000	RE fruit	PRR	2011
5	101	0.377	40.304	0.000	1.179	0.000	RE fruit	PRR	2011
5	100	0.000	35.386	0.000	0.000	0.000	RE leaf	PRR	2011
6	102	0.000	31.400	0.000	0.000	0.000	RE fruit	PRR	2011
6	106	0.000	39.675	0.000	0.000	0.000	RE fruit	PRR	2011
6	104	0.000	14.644	1.024	3.445	0.564	RE other	PRR	2011
6	105	1.105	27.378	0.000	0.197	0.000	RE leaf	PRR	2011
7a	107	0.000	13.596	0.000	0.000	0.000	CC fruit	PRR	2011
7a	108	0.000	12.217	0.000	0.000	0.000	CC other	PRR	2011
7a	110	0.000	77.226	0.000	0.000	0.000	GR fruit	PRR	2011
7a	118	1.108	43.370	0.286	2.907	0.000	GR fruit	PRR	2011
7a	111	0.000	27.468	0.000	5.493	0.000	GR other	PRR	2011
7a	120	0.275	18.565	0.000	2.295	0.000	GR leaf	PRR	2011
7a	121	0.000	69.385	0.000	6.517	0.000	RE leaf	PRR	2011
7b	112	0.000	27.431	0.000	0.000	0.000	CC fruit	PRR	2011
7b	113	0.000	15.275	0.000	0.000	0.000	CC other	PRR	2011
7b	114	0.000	45.211	0.000	5.568	0.000	PL fruit	PRR	2011
7b	115	0.000	11.463	0.000	3.230	0.623	PL leaf	PRR	2011
7b	116	0.000	12.352	0.000	1.084	0.000	RE fruit	PRR	2011
7b	122	0.135	54.446	0.000	5.314	0.000	RE fruit	PRR	2011
7b	117	2.205	17.612	0.000	0.000	0.000	RE other	PRR	2011

Table I-1, continued.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
8a	124	0.821	10.548	0.000	6.213	0.000	BC other	PRR	2011
8a	125	0.660	40.239	0.000	5.103	0.000	CC fruit	PRR	2011
8a	126	0.000	2.263	0.000	6.553	0.000	CC other	PRR	2011
8a	128	0.000	69.539	0.000	2.264	0.000	PL other	PRR	2011
8b	129	0.000	20.937	0.550	3.870	0.851	BC leaf	PRR	2011
8b	130	0.000	87.289	0.000	1.625	0.000	RE fruit	PRR	2011
8b	132	0.000	66.436	0.033	8.943	0.000	RE fruit	PRR	2011
8b	131	2.359	39.255	0.000	0.000	0.000	RE leaf	PRR	2011
9	133	0.000	23.360	0.000	7.470	0.000	BC other	PRR	2011
9	135	1.710	0.000	0.000	0.000	0.000	BC leaf	PRR	2011
9	136	0.785	0.000	0.000	2.222	0.000	CC leaf	PRR	2011
9	137	0.000	0.107	0.000	2.699	0.000	PL leaf	PRR	2011
9	138	0.000	0.000	0.000	0.000	0.000	RE fruit	PRR	2011
9	140	1.865	0.000	0.000	2.916	0.000	RE fruit	PRR	2011
9	139	1.216	0.000	0.000	0.000	0.000	RE leaf	PRR	2011
10	141	0.000	0.000	0.049	3.955	0.000	CC fruit	PRR	2011
10	142	0.000	9.779	0.000	3.596	0.720	CC other	PRR	2011
10	143	0.000	44.211	0.000	4.593	0.000	CC leaf	PRR	2011
10	145	0.000	67.446	0.000	0.000	0.000	GR fruit	PRR	2011
10	150	0.571	31.051	0.000	4.119	0.000	GR fruit	PRR	2011
10	146	0.145	44.041	0.000	0.553	0.000	GR other	PRR	2011
10	148	3.203	31.251	0.000	1.172	0.000	RE fruit	PRR	2011
10	151	0.000	27.181	0.148	1.026	0.000	RE fruit	PRR	2011
10	149	1.118	14.826	0.000	3.435	0.000	RE leaf	PRR	2011
mean		0.44	33.33	0.03	3.23	0.27			
range		0-3.20	0-227.35	0-1.02	0-40.35	0-13.59			
standard dev.		0.75	37.60	0.13	5.59	1.44			
# ND		61/98	8/98	86/98	28/98	87/98			
% ND		62.2%	8.2%	87/8%	28/6%	88/8%			

Table I-2. Wild rosehips along White River, Sites 11-15, 2012. Yellow highlights indicate highest score in the range.

Site	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
11a	0.000	5.860	0.364	0.766	4.620	RE fruit	Dawes Co, NE	2012
12a	0.902	36.100	0.687	0.031	6.500	RE fruit	PRR	2012
13a	0.000	7.560	0.000	1.590	3.300	RE fruit	PRR	2012
14a	0.284	9.470	0.281	0.000	5.170	RE fruit	PRR	2012
15a	0.000	14.700	0.010	1.220	6.220	RE fruit	Jackson Co., SD	2012
mean	0.24	14.74	0.27	0.72	5.16			
range	0-0.90	5.86-36.10	0-0.69	0.03-1.60	3.30-6.50			
std. dev.	0.35	11.09	0.25	0.63	1.16			
range	0-0.90	5.9-36.10	0-0.69	0-1.60	3.30-6.50			
# ND	3/5	0/5	1/5	1/5	0/5			
% ND	60%	0%	20%	20%	0%			

Table I-3. Soils along White River, Sites 11-15, 2012.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
11a	5.290	258.000	8.440	0.000	29.9	Soil surface	Dawes Co., NE	2012
11b	4.180	263.000	9.140	0.265	31.9	Soil surface	Dawes Co., NE	2012
12a	4.760	340.000	18.300	0.577	32.4	Soil surface	PRR	2012
12b	7.170	413.000	9.940	0.366	32.1	Soil surface	PRR	2012
13a	6.100	654.000	7.930	0.000	21.6	Soil surface	PRR	2012
13b	5.920	345.000	7.460	0.000	28.7	Soil surface	PRR	2012
14b	4.470	337.500	7.040	0.000	27.8	Soil surface	Jackson Co., SD	2012
15a	4.870	288.000	8.400	0.000	25.1	Soil surface	PRR	2012
15b	3.460	401.000	6.550	0.000	19.8	Soil Surface	PRR	2012
mean	5.136	366.611	9.244	0.134	27.700			
range	3.46-7.17	258-654	6.55-18.30	0-0.58	19.80-32.40			
std. dev.	1.06	113.85	3.35	0.20	4.36			
# ND	0/9	0/9	0/9	6/9	0/9			
% ND	0%	0%	0%	67%	0%			

Table I-4. Soils, PRR locale, Sites 1-10, 2011. Yellow highlights indicate highest score in the range.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
1a	3.713	13.219	16.219	5.187	13.827	soil surface	PRR	2011
1a	3.545	257.114	7.674	7.330	5.083	soil 25.4 cm	PRR	2011
1a	2.768	205.914	6.417	8.987	13.616	soil 50.8 cm	PRR	2011
1a	0.000	207.197	6.146	1.518	5.949	soil 76.2 cm	PRR	2011
1b	0.000	186.207	10.319	8.325	6.338	soil surface	PRR	2011
1b	2.795	224.016	9.005	2.046	11.156	soil 25.4 cm	PRR	2011
1b	0.000	235.546	7.148	6.644	5.106	soil 50.8 cm	PRR	2011
1b	3.638	194.620	6.973	10.404	9.472	soil 76.2 cm	PRR	2011
2a	1.867	229.427	12.552	10.324	14.286	soil surface	PRR	2011
2a	1.309	220.404	8.739	6.650	4.970	soil 25.4 cm	PRR	2011
2a	3.755	203.967	9.125	5.896	9.842	soil 50.8 cm	PRR	2011
2a	4.195	213.082	7.602	4.558	9.563	soil 76.2 cm	PRR	2011
2b	1.073	658.835	12.698	9.331	14.893	soil surface	PRR	2011
2b	2.666	216.054	7.343	8.632	0.000	soil 25.4 cm	PRR	2011
2b	4.617	201.159	7.848	7.104	0.000	soil 50.8 cm	PRR	2011
2b	2.639	180.979	7.507	7.140	7.167	soil 76.2 cm	PRR	2011
3a	3.180	244.636	7.121	8.152	20.695	soil surface	PRR	2011
3a	0.274	182.354	6.796	12.518	7.709	soil 25.4 cm	PRR	2011
3a	0.000	188.872	6.305	1.674	2.868	soil 50.8 cm	PRR	2011
3a	0.000	180.979	6.479	10.581	21.330	soil 76.2 cm	PRR	2011
3b	0.000	209.645	6.761	6.529	14.119	soil surface	PRR	2011
3b	0.521	210.715	5.836	3.857	0.000	soil 25.4 cm	PRR	2011
3b	0.000	247.883	6.284	5.725	10.494	soil 50.8 cm	PRR	2011
3b	1.310	1311.865	7.382	6.543	1.124	soil 76.2 cm	PRR	2011
4a	5.560	313.423	7.820	9.387	17.468	soil surface	PRR	2011
4a	6.295	312.735	8.664	3.304	15.351	soil 25.4 cm	PRR	2011
4a	12.302	314.950	28.445	12.690	11.769	soil 50.8 cm	PRR	2011
4a	6.933	142.108	7.794	9.784	1.163	soil 76.2 cm	PRR	2011
4b	7.248	303.430	10.088	7.874	14.533	soil surface	PRR	2011
4b	2.735	320.246	8.604	11.575	10.218	soil 25.4 cm	PRR	2011
4b	5.504	242.317	6.848	6.560	10.981	soil 50.8 cm	PRR	2011
4b	4.554	677.153	6.901	5.276	16.332	soil 76.2 cm	PRR	2011

Table I-4, continued

Site	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
5	0.000	245.898	15.061	5.904	20.539	soil surface	PRR	2011
5	2.184	189.822	13.168	5.314	16.959	soil 25.4 cm	PRR	2011
5	6.817	160.849	11.777	6.541	9.054	soil 50.8 cm	PRR	2011
5	2.395	252.882	11.420	6.811	4.127	soil 76.2 cm	PRR	2011
6	1.701	251.764	13.601	7.591	18.296	soil surface	PRR	2011
6	5.725	253.549	10.447	9.662	13.828	soil 25.4 cm	PRR	2011
6	2.338	268.372	7.517	7.271	4.929	soil 50.8 cm	PRR	2011
6	3.057	239.048	7.612	11.136	17.907	soil 76.2 cm	PRR	2011
7a	3.321	386.184	6.289	3.981	9.844	soil surface	PRR	2011
7a	4.302	139.529	6.347	9.732	1.901	soil 25.4 cm	PRR	2011
7a	5.660	145.334	5.477	8.168	4.236	soil 50.8 cm	PRR	2011
7a	6.920	204.083	5.329	7.823	5.329	soil 76.2 cm	PRR	2011
7b	1.914	407.821	7.026	1.508	4.793	soil surface	PRR	2011
7b	1.891	176.200	3.913	6.934	1.281	soil 25.4 cm	PRR	2011
7b	5.126	265.397	5.913	9.830	29.352	soil 50.8 cm	PRR	2011
7b	3.750	450.090	6.724	6.349	21.095	soil 76.2 cm	PRR	2011
8a	3.176	552.741	7.625	8.651	12.659	soil surface	PRR	2011
8a	6.062	247.686	6.039	8.309	6.200	soil 25.4 cm	PRR	2011
8a	2.426	271.568	6.991	8.547	2.126	soil 50.8 cm	PRR	2011
8a	1.334	255.913	6.562	2.137	7.114	soil 76.2 cm	PRR	2011
8b	2.281	270.487	8.567	2.803	35.942	soil surface	PRR	2011
8b	5.012	254.479	7.128	9.937	27.945	soil 25.4 cm	PRR	2011
8b	4.751	283.934	6.196	6.517	28.554	soil 50.8 cm	PRR	2011
8b	0.000	251.566	7.265	6.709	17.756	soil 76.2 cm	PRR	2011
9	1.461	262.686	18.100	7.297	20.821	soil surface	PRR	2011
9	5.135	458.750	12.511	5.190	18.248	soil 25.4 cm	PRR	2011
9	4.247	731.951	12.881	0.860	2.584	soil 50.8 cm	PRR	2011
10	3.520	475.944	10.502	6.432	15.563	soil surface	PRR	2011
10	0.635	619.230	11.093	6.776	16.395	soil 25.4 cm	PRR	2011
10	2.668	642.228	11.691	7.645	11.258	soil 50.8 cm	PRR	2011
10	1.092	543.415	11.007	9.343	6.420	soil 76.2 cm	PRR	2011
mean	3.11	304.93	8.94	7.05	11.44			
range	0-12.30	13.22-1311.87	3.1-28.45	.086-12.69	0-35.94			
std. dev.	2.36	192.71	3.77	2.71	7.85			
# ND	9/63	0/63	0/63	1/63	0/63			
% ND	14.3%	0%	0%	0%	1.6%			

Table I-5. Rosehips, Brookings County, SD, comparison Sites B-1 through B-30, 2011. Yellow highlights indicate highest score in the range.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
B1	0.000	25.306	0.000	1.051	0.000	RE, fruit	Brookings	2011
B2	0.000	5.225	0.000	5.198	0.000	RE, fruit	Brookings	2011
B3	0.000	1.653	0.000	0.000	0.000	RE, fruit	Brookings	2011
B4	0.000	2.342	0.000	5.487	0.000	RE, fruit	Brookings	2011
B5	0.000	2.989	0.000	6.810	0.000	RE, fruit	Brookings	2011
B6	0.000	11.452	0.000	2.547	0.000	RE, fruit	Brookings	2011
B7	0.000	15.068	0.000	3.743	0.000	RE, fruit	Brookings	2011
B8	1.321	6.304	0.000	0.000	0.000	RE, fruit	Brookings	2011
B9	0.000	5.468	0.000	0.000	0.000	RE, fruit	Brookings	2011
B10	0.000	7.835	0.000	2.520	0.000	RE, fruit	Brookings	2011
B11	0.000	3.751	0.000	2.292	0.000	RE, fruit	Brookings	2011
B12	2.073	15.510	0.000	1.427	0.000	RE, fruit	Brookings	2011
B13	2.550	2.302	0.146	2.983	0.000	RE, fruit	Brookings	2011
B14	1.110	5.306	1.665	5.902	0.000	RE, fruit	Brookings	2011
B15	0.000	4.786	0.000	2.571	0.000	RE, fruit	Brookings	2011
B16	0.039	4.226	0.247	10.254	0.000	RE, fruit	Brookings	2011
B17	0.000	16.052	0.000	3.317	0.000	RE, fruit	Brookings	2011
B18	0.000	2.605	0.000	3.224	0.000	RE, fruit	Brookings	2011
B19	0.000	6.534	0.237	0.000	0.000	RE, fruit	Brookings	2011
B20	0.000	4.982	0.000	2.441	0.000	RE, fruit	Brookings	2011
B21	0.000	9.019	0.000	0.000	0.000	RE, fruit	Brookings	2011
B22	0.000	4.862	0.000	2.397	0.000	RE, fruit	Brookings	2011
B23	0.000	5.435	0.000	0.000	0.000	RE, fruit	Brookings	2011
B24	0.000	2.142	0.091	4.625	0.000	RE, fruit	Brookings	2011
B25	0.000	0.454	0.000	3.395	0.000	RE, fruit	Brookings	2011
B26	0.693	3.108	0.000	0.770	0.000	RE, fruit	Brookings	2011
B27	0.000	12.169	0.125	2.448	0.000	RE, fruit	Brookings	2011
B28	0.000	7.720	0.000	4.247	0.000	RE, fruit	Brookings	2011
B29	0.000	5.757	0.000	0.840	0.000	RE, fruit	Brookings	2011
B30	0.000	7.785	0.000	1.436	0.000	RE, fruit	Brookings	2011
mean	0.260	6.938	0.084	2.731	ND			
range	0-2.56	0.45-25.31	0-1.67	0-10.25	ND			
standard dev.	0.64	5.29	0.30	2.34	0.00			
# ND	24/30	0/30	24/30	6/30	30/30			
% ND	80%	0%	80%	20%	100%			

APPENDIX J: LOCATION OF SITES

Table J-1. GPS all sites, 2011-2012.

Site	x= Pine Ridge Reservation, SD or *=bordering	Latitude N degrees	Longitude W degrees		Site	x=Brookings County, SD	Longitude N degrees	Latitude W degrees
1	x	43.3683	102.2509		B1	x	44.4514	96.9475
2	x	43.2381	102.4701		B2	x	44.4702	97.0001
3	x	43.1375	102.3724		B3	x	44.4846	96.9724
4	x	43.0898	102.7977		B4	x	44.3229	96.7080
5	x	43.4853	102.8807		B5	x	44.3335	96.6880
6	x	43.5114	102.4981		B6	x	44.3661	96.7477
7	x	43.6580	102.8947		B7	x	44.3596	96.7880
8	x	43.5351	101.9881		B8	x	44.3382	96.8202
9	x	43.6099	101.5027		B9	x	44.3471	96.8288
10	x	43.5627	101.3129		B10	x	44.3554	96.8533
11	*	42.8861	103.0667		B11	x	44.3553	96.8294
12	x	43.3136	102.7887		B12	x	44.3556	96.8928
13	x	43.5081	102.5055		B13	x	44.3560	96.8876
14	*	43.6942	101.9348		B14	x	44.3842	96.8928
15	x	43.7520	101.5260		B15	x	44.4062	96.9069
					B16	x	44.3937	96.8488
					B17	x	44.2684	96.7684
					B18	x	44.2534	96.7689
					B19	x	44.2400	96.7671
					B20	x	44.2369	96.7677
					B21	x	44.2534	96.7751
					B22	x	44.2534	96.7711
					B23	x	44.2356	96.7470
					B24	x	44.2132	96.7469
					B25	x	44.2501	96.7071
					B26	x	44.2538	96.6823
					B27	x	44.2550	96.6674
					B28	x	44.2849	96.6673
					B29	x	44.2462	96.7682
					B30	x	44.2535	96.7641

APPENDIX K: CALCULATIONS

Table K-1. Calculations for US CDC MRL comparisons of chronic yearly doses of heavy metals in fruits, Sites 1-15, near and on PRR, 2011 and 2012. Yellow highlights indicate potential maximum number of cups meeting MRL standards, as well as number of persons and percentage of persons above allowed MRL dosage per fruit, not including total dose for all fruits consumed.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Fruit	Heavy metal species in US CDC standard	Maximum reported fruit, estimated as freshly picked, and used by individual per year, cups [1 c. volume=0.24 L]	Dry weight per cup kg	Arithmetic mean of samples mg/kg	Highest score in range of samples mg/kg	Yearly "dose" arithmetic mean mg	Yearly "dose" highest score in range mg	Minimal Risk Levels MRLs heavy metal baseline mg	Body weight standard kg	Days of chronic oral use	Exposure in mgs of heavy metal/ kg of body weight/ 365 days (except uranium/364 days)	# persons/ % above lowest MRL dosage *	Effective date US CDC standard
Buffalo currant	arsenic	100	0.02117	1.288	2.577	2.7273	5.455509	0.0003	55	365	6.0225		Aug. 2007
	barium soluble salts	100	0.02117	10.154	15.341	21.4960	32.476897	0.2000	55	365	4015.0000		Aug. 2007
	lead	100	0.02117	NA & ND	NA & ND	NA & ND	NA & ND	not established	55	365	NA & ND		NA
	selenium	100	0.02117	2.256	2.297	4.775952	4.862749	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	100	0.02117	ND	ND	ND	ND	0.0002	55	364	4.0040		Feb. 2013
Chokecherry	arsenic	150	0.05161	0.319	1.933	2.4669	14.9643	0.0003	55	365	6.0225		Aug. 2007
	arsenic	80	0.05161	0.319	1.933	1.3157	7.9810	0.0003	55	365	6.0225		Aug. 2007
	arsenic *	16	0.05161	0.319	1.933	0.2631	1.5962	0.0003	55	365	6.0225	4 persons/ 12.5%	Aug. 2007
	barium soluble salts	150	0.05161	27.385	58.71	212.0022	454.5035	0.2000	55	365	4015.0000		Aug. 2007
	lead	150	0.05161	0.014	0.074	0.1055	0.5729	not established	55	365	NA		NA
	selenium	150	0.05161	2.839	7.417	21.9767	57.4187	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	150	0.05161	ND	ND	ND	ND	0.0002	55	364	4.0040		Feb. 2013
Wild grape	arsenic	80	0.03696	0.420	1.108	1.241	3.2761	0.0003	55	365	6.0225		Aug. 2007
	barium soluble salts	80	0.03696	54.773	77.226	161.954	228.3418	0.2000	55	365	4015.0000		Aug. 2007
	lead	80	0.03696	1.757	0.286	5.194	0.8456	not established	55	365	NA		NA
	selenium	80	0.03696	1.757	4.119	5.194	12.1791	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	80	0.03696	ND	ND	ND	ND	0.0002	55	364	4.0040		Feb. 2013
Wild plum	arsenic	150	0.0247	0.258	1.033	0.9567	3.8273	0.0003	55	365	6.0225		Aug. 2007
	barium soluble salts	150	0.0247	69.187	178.236	256.3394	660.3644	0.2000	55	365	4015.0000		Aug. 2007
	lead	150	0.0247	0.003	0.013	0.01191	0.0482	not established	55	365	NA		NA
	selenium and compounds	150	0.0247	5.142	8.897	19.0515	32.9634	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	150	0.0247	0.723	2.893	2.6794	10.7186	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	80	0.0247	0.723	2.893	1.4290	5.7166	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts *	32	0.0247	0.723	2.893	0.5716	2.2866	0.0002	55	364	4.0040	2 persons/ 6%	Feb. 2013
Wild rose	arsenic	64	0.05364	0.409	3.203	1.4049	10.9958	0.0003	55	365	6.0225		Aug. 2007
	arsenic *	16	0.05364	0.409	3.203	0.3510	2.7489	0.0003	55	365	6.0225	1 person/ 3%	Aug. 2007
	barium soluble salts	64	0.05364	34.943	211.506	119.9585	726.0916	0.2000	55	365	4015.0000		Aug. 2007
	lead	64	0.05364	0.056	0.687	0.1936	2.3584	not established	55	365	NA		NA
	selenium	64	0.05364	1.941	8.943	46.6436	30.7010	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	64	0.05364	1.459	13.587	5.0091	46.6436	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	16	0.05364	1.459	13.587	1.2522	11.6609	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	10	0.05364	1.459	13.587	0.7825	7.2881	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	6	0.05364	1.459	13.587	0.4695	4.3728	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts *	2	0.05364	1.459	13.587	0.1565	1.4576	0.0002	55	364	4.0040	4 persons/ 12.5%	Feb. 2013

Table K-2. Calculations for US CDC MRL comparisons of chronic yearly doses of heavy metals in fruits, Sites B1 through B30, Brookings County, SD, 2011.

Fruit	Heavy metal species in US CDC standard	Number of cups per year, fresh, volume (1 c. = 0.24 L)	Yearly "dose" based on arithmetic mean mg	Yearly "dose" based on highest score in range mg	Body weight standard kg	Days of chronic oral use	MRL conversion mg of heavy metal/ kg of body weight/ 365 days (except uranium/364 days)
Wild rose	arsenic	64	0.089	8.788	55	365	6.0225
	barium soluble salts	64	23.818	80.022	55	365	4015.0000
	lead	64	0.288	5.733	55	365	NA
	selenium	64	9.375	35.188	55	365	100.3750
	uranium soluble salts	64	ND	ND	55	364	4.0040

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